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95th Congress
2d Session

COMMITTEE PRINT

Committee
Print 95–48

THE NATIONAL ENERGY PLAN

OPTIONS UNDER ASSUMPTIONS OF NATIONAL SECURITY THREAT

A REPORT

WITH

SELECTED READINGS

PREPARED BY THE

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SUBCOMMITTEE ON ENERGY AND POWER

OF THE

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LETTER OF TRANSMITTAL

Hon. Harley O. Staggers,
Chairman, Committee on Interstate and Foreign Commerce, U.S. House of Representatives, Rayburn House Office Building, Washington, D.C.

Dear Mr. Chairman: At my request, the Library of Congress has prepared an analysis of additional tools available to the U.S. Government in its efforts to induce significant changes in the direction of our national energy policy. A copy of this analysis, entitled "The National Energy Plan: Options Under Assumptions of National Security Threat" with selected readings is enclosed.

The central thesis of this paper is that if there are important national security implications to our present energy posture, then we should recognize those implications and take action to reduce the very real risks to which we are presently exposed. We have taken similar steps in the past. Such steps could be taken now, if needed. Although we may not agree with all aspects of this analysis, it is thought provoking and worthy of further study.

We have a national responsibility to examine all of the ranges of steps which might be taken to reduce our vulnerability, and not merely those endorsed in the National Energy Plan. In my view, the enclosed report merits careful review. I intend to forward it to the DOE with a request that they provide that review.

Sincerely,

John D. Dingell,
Chairman,
Subcommittee on Energy and Power.

LETTER OF SUBMITTAL

LIBRARY OF CONGRESS,
CONGRESSIONAL RESEARCH SERVICE,
Washington, D.C., February 17, 1978.

Hon. JOHN D. DINGELL,
Chairman, Subcommittee on Energy and Power, U.S. House of Representatives, Washington, D.C.

DEAR MR. DINGELL: I am pleased to submit a report to you, entitled "The National Energy Plan: Options Under Assumptions of National Security Threat." The report and selected readings were prepared and compiled by the Environment and Natural Resources Policy Division. Frances A. Gulick and Joseph P. Biniek, Analyst and Specialist, respectively, were responsible for the preparation and compilation of these materials.

As you requested, the report addresses the energy problem in the context of an assumed national security threat along the lines postulated by the executive branch over the past year. The text and the appended readings illustrate options available for Government action under this assumption.

I hope this report will be useful to you and your committee in your continuing consideration of energy policy options.

Sincerely,

GILBERT GUDE,
Director, Congressional Research Service.

CONTENTS

Page

Letter of transmittal ---------- III
Letter of submittal ---------- V
Foreword ---------- IX
Abstract and introduction ---------- 1
The national energy plan in national security terms ---------- 4
  The President's assessment ---------- 4
  Statement by the Secretary of Defense ---------- 5
Primary Federal tasks in a national security response ---------- 5
  Primary Executive responsibility ---------- 6
  The supporting congressional role ---------- 6
National energy principles in the context of a national security response ---------- 6
  The 10 principles ---------- 7
  The Federal role ---------- 7
  The role of conservation and production ---------- 8
  Energy pricing concepts ---------- 10
A national security orientation for the national energy plan ---------- 12
  Executive measures ---------- 12
    Define the nature of the threat to security ---------- 12
    Set quantitative targets ---------- 12
    Place orders for large scale Federal procurement of goods and services ---------- 13
    Determine priority access to critical materials and restrict uses when required by national security ---------- 14
    Enlist and mobilize broad public and private sector participation and support ---------- 15
    Maintain the strength of the international collective security system ---------- 16
  Legislative measures ---------- 17
Table: Federal procurement opportunities for increasing private sector industrial production capacity for selected oil-saving products ---------- 18
Annex I: Preliminary assessments of the impact of the plan on the oil import savings goals (excerpts from CRS issue brief 77060) updated February 5, 1977 ---------- 19

SELECTED READINGS

A. Selected statements on the energy problem and national security:

  "National Energy Plan," the President's address to the Nation, November 8, 1977 ---------- 23
  Statement of Hon. Harold Brown, Secretary of Defense before the House Ad Hoc Committee on Energy, May 4, 1977 ---------- 28
  A Statement by the chairman of the House Ad Hoc Committee on Energy, Hon. Thomas L. Ashley, October 12, 1977 ---------- 31
  Decision on group objectives and principles for energy policy adopted by the Governing Board of the IEA meeting at the ministerial level on October 5, 1977 ---------- 32
  Statement of Hon. James Schlesinger, U.S. Secretary of Energy to the meeting of the Governing Board of the International Energy Agency at the ministerial level, October 5, 1977 ---------- 34
  "Energy in the Coming Decade," by Hon. Richard N. Cooper, Under Secretary of State for Economic Affairs, December 8, 1977 ---------- 37

- B. Federal procurement options:
  - Testimony of Hon. Harold Brown before the House Ad Hoc Committee on Energy, May 4, 1977:
    - "Department of Defense Procurement on Petroleum From Foreign Sources" ---- Page 43
    - "Petroleum Reserve Inventories" ---- 44
    - "Department of Defense Initiatives on Use of Synthetic Fuels in Military Applications" ---- 45
  - A dialog on synfuels between Hon. Joseph Fisher and Secretary Harold Brown, May 4, 1977 ---- 47
  - "Estimate of National Hydroelectric Power Potential at Existing Dams," U.S. Corps of Engineers, July 20, 1977 ---- 48
  - "Power Production at Federal Dams Could Be Increased by Modernizing Turbines and Generators," U.S. General Accounting Office, March 1977 ---- 129
  - A dialog on vehicles between Hon. James Martin and Secretary Schlesinger before the House Ad Hoc Committee on Energy, May 5, 1977 ---- 136
  - ERDA electric and hybrid demonstration program, March 1977 ---- 138
  - "Potential for Using Electric Vehicles on Federal Installations," Comptroller General of the United States, March 3, 1976 ---- 165
  - "Federal Motor Vehicle Fleet Report Fiscal Year 1976," General Services Administration, June 1977 ---- 176
  - "Application of Solar Technology to Today's Energy Needs," U.S. Congress, Office of Technology Assessment, June 1977 (Excerpts) ---- 190
    - "Can Purchases of Solar Equipment for Federal Buildings be Used to Stimulate the Solar Industry?" ---- 190
    - "Solar Energy and Federal Buildings: The Current Program" ---- 193
    - "The Potential of Individual Agencies" ---- 194
    - "What Are the Main Problems in Gaining Wider Acceptance for Solar Energy Technology and What Can be Done To Solve Them?" ---- 198
    - "Impact of Solar Energy on U.S. Security and Trade" ---- 199
    - "Impact of Solar Energy on American Labor" ---- 212
  - "Resource Requirements and Displacement of Alternative Energy Sources," Solar Program Assessment: Environmental Factors—Solar Total Energy Systems, ERDA 77-47/5, March 1977 ---- 221
  - "Material Resource Requirements," Solar Program Assessment: Environmental Factors—Solar Heating and Cooling of Buildings, ERDA 77-47/1, March 1977 ---- 222
  - "Preliminary Analysis of an Option for the Federal Photovoltaic Utilization Program," Task Force on Solar Energy Commercialization, Federal Energy Administration, July 20, 1977 ---- 223
  - A Solar-Heated Hospital. The Navy Civil Engineer. Spring, 1977 ---- 275
- C. Oil import quotas and fees:
  - Supreme Court decision, *Algonquin SNG* v. *FEA* ---- 281
  - Excerpt from "Energy Legislation in the 94th Congress," Committee Print, Senate Committee on Interior and Insular Affairs ---- 290
- D. Production incentives and assistance:
  - Industrial Mobilization and Procurement, excerpt from "The Sinews of War: Army Logistics 1775-1953," by James A. Huston, Office of the Chief of Military History, United States Army, 1966 ---- 301
  - Examples of governmental financing for petroleum-related products and facilities during World War II, from "A History of the Petroleum Administration for War," 1946 ---- 310
  - "The Technical Oil Mission," a brief report on a program to collect European synfuel and other technical information during World War II ---- 328
  - Selected materials describing the controlled materials plan ---- 330
- E. Mobilizing public and private support:
  - "Administrative Reflections from World War II," Luther Gulick, University of Alabama Press, 1948 ---- 389
  - "In Search of a National Energy Plan," by David Morris in Self Reliance, November/December 1977 ---- 395
  - "A Note on Sectoral Planning in a Democracy," excerpt from a Preliminary Assessment of the President's National Energy Plan, by W. W. Rostow, William Fisher, and George Kozmetsky, University of Texas (Austin), May 11, 1977 ---- 400
- F. Additional references ---- 403

FOREWORD

The quote by William James used by President Carter in describing the U.S. energy situation as the "moral equivalent of war" has now been sufficiently repeated to warrant its designation as a cliche. Nonetheless, the reality of the situation that led to the President's energy message is increasingly apparent. The ability of the United States to meet its present and projected energy demand with domestic resources is decreasing. One result of this has been an increasing reliance on imported fuels.

In addition to detrimentally affecting the world economic balance, heavy U.S. dependence on foreign fuel supplies could pose a future threat to national security. The disastrous effects of an interruption in fuel supply were seen during the 1973 oil embargo and the winter of 1976–77 natural gas shortages, and are being seen now as a result of the recent nationwide coal strike. Future oil embargoes could cripple the United States and put it at the mercy of the major oil-supplying nations, thus seriously threatening national security.

The President's National Energy Program deals with domestic energy problems and solutions. However, since the energy situation has international implications as well, it is equally important to address potential international problems, in particular the threat to national security, and to know what options are available to the Federal Government to deal with such problems.

As the chairman of the Energy and Power Subcommittee, I requested the Congressional Research Service of the Library of Congress to conduct a study to identify the types of programs that could adequately deal with an energy-induced national security crisis. Whether members of the subcommittee agree with all of the analysis or not, the report compiled by Ms. Frances A. Gulick and Joseph P. Biniek of CRS in response to my request will be a useful aid to anyone concerned with the formation and implementation of national energy policies.

John D. Dingell,
Chairman, Subcommittee on Energy and Power, Committee on Interstate and Foreign Commerce, House of Representatives.

ABSTRACT

PURPOSE AND SCOPE

In presenting his national energy program, the President based his case for that set of extraordinary measures on a perception of a serious threat to national and free world security. That threat would mature to crisis in the mid-1980's, as projected by the President, when world suppliers of oil would be unable or unwilling to provide enough oil to meet world needs and prevent economic chaos. In this analysis, the dependence of the U.S. and the free world on imported oil places free world economic, political, and military health at grave near-term risk, requiring an accelerated program to reduce oil import dependence and a shift to other fuels, all with the equivalent of wartime urgency, vigor, and scale.

During the ensuing months of executive and congressional action, many commentators have noted that neither the concrete elements of the President's plan nor the nature and pace of congressional action have been consistent with a credibly projected near-term national security crisis.

In response to a congressional request, this paper explores the types of programs and rationales that would be consistent with a credible, near-term national security threat of the nature described above, based upon analogous or comparable war-related mobilizations in the past. This analysis does not assess the relative merits of the President's projection of national security threat of crisis dimensions against other less drastic interpretations but accepts that projection and the need for wartime emergency measures as assumptions for this paper.

THE LEADING EXECUTIVE ROLE

A serious threat to national security always calls for a leading Federal role. In previous instances, the executive branch has taken the responsibility for getting done whatever was necessary. Congress has provided support, funds, oversight, and sometimes legislative authority after the fact.

In an energy crisis that threatens the national security, the executive branch could be expected to assume and exercise major authorities dealing with both the supply and the use of fuels and energy. Tasks which the executive branch has assumed in the past in situations of real emergency include:

1. Defining the nature of the threat to security.
2. Setting production targets and mobilizing the U.S. industrial base for expanding the domestic supply of fuels and energy, munitions and industrial products needed to meet the emergency.
3. Placing large orders for the goods and services required to carry out direct Federal operations.
4. Setting priorities for use of critical materials and restricting their use by industry.

5. Enlisting and mobilizing public and private participation and support.
6. Maintaining the strength of the international collective security system.

INDUSTRIAL MOBILIZATION FOR NATIONAL GOALS

In earlier instances of national security emergency, large scale direct Federal procurement of goods and services in pursuit of industrial production goals alined with national security objectives provided the primary Federal management tool by which such national goals could be both established and achieved.

Although the Federal Government set the production goals, the speed with which the targets were achieved depended on a close partnership between the Federal Government and private industry. This involved an exercise of Federal regulatory authority to allocate scarce materials, coupled with restrictions as required to limit non-priority uses, which was put at the service of the U.S. private industrial production sector, and close mutual exchange of information.

A similar partnership is possible now to fulfill the quantitative goals set in the national energy plan, accelerating the production of equipment and facilities using renewable and other fuels alternative to oil, through large-scale Federal purchases for its own use of such items as the following:

1. Synthetic fuels, including oil from shale and coal, fuel from waste and gasoline substitutes.
2. Electric or other non-gasoline-using vehicles.
3. Solar heating and cooling, photovoltaic and wind energy conversion systems.
4. Industrial facilities for waste recycling, cogeneration of heat, environmental protection, hydro-electric turbines and generators, fluidized bed combustors and other equipment permitting retrofit for the use of fuels other than oil.

Since the Federal Government owns, annually procures, and maintains hundreds of thousands of buildings and vehicles for its own public services, accelerated procurement for replacing and retrofitting existing federally owned capital stock could be sufficient to underwrite and accelerate an expanding private industrial production capability in equipment using fuels other than oil.

The public market for such equipment may be enlarged by enlistment of State and local government purchases for which Federal fiscal or other assistance may be provided.

FEDERAL INTERVENTION IS LIMITED IN TIME

During World War II and the Korean war, substantial Federal intervention and redirection of private industrial production to meet national security production goals was accepted in large measure because it was conceived of as essentially temporary, "for the duration." There was general agreement on the wartime goals—defense of democracy, defeat of its foes—but there was also general agreement that, with victory, national production would revert to private hands, its output again determined by civilian consumption choices and needs.

Clearly, a direct analogy cannot be drawn with the present situation. "Victory" will not be "won" by 1985: Under the most optimistic scenario proposed, achievement of the plan's 1985 energy goals would still leave the United States depending on annual imports of about 6 million barrels of oil a day. However, the accelerated Federal procurement program explored in this paper as an option would not be needed after 1985. It is expected that by then private sector demand could and would take over the process of expanding the volume and scope of the Nation's conversion to the use of fuels other than oil.

THE CONGRESSIONAL ROLE

Historically, legislative measures enacted during periods of national security or wartime emergencies have served primarily to support Presidential initiatives and decisions with such additional tax and other authorizations and appropriations as were considered necessary. Any or all of the Executive measures outlined in the preceding section could be launched by the President under authorities and congressional consent procedures in laws still in force.

However, Congress is by no means prevented from taking much stronger initiatives independently or supplementing Executive initiatives in dealing with situations involving risk to national security. Congress retains and may wish to exercise the option to assume a much stronger leading role in the design and rationale of new national policies intended to reduce U.S. dependence on imported oil, and independently promote the Federal procurement and other oil import saving programs which could realize in time this national security goal.

The following paper, together with selected additional readings, elaborates some options available under the assumption that continuing substantial dependence on imported oil presents an unacceptable threat to the national security of the United States and its allies.

The National Energy Plan in National Security Terms

The President has defined the energy problem facing this country as one of grave and near-term danger to national security. He set U.S. energy demands in a world context, as an approaching crisis of the mid-1980's when world suppliers of oil would not be able or willing to export all the oil needed by the United States and the free world. The resulting international tensions, competition for imports of oil, and slowdown in the free world's economy would threaten "national catastrophe." The crisis point sometime in the 1980's, according to the President's perspective, is not self-imposed but will be determined by world events and trends which are now largely outside of domestic control.

THE PRESIDENT'S ASSESSMENT

In a nationwide address April 18, 1977, the President described the approaching dangers in very strong terms.[1]

> Tonight I want to have an unpleasant talk with you about a problem that is unprecedented in our history. With the exception of preventing war, this is the greatest challenge that our country will face during our lifetime.
>
> The energy crisis has not yet overwhelmed us, but it will if we do not act quickly * * *.
>
> The oil and natural gas that we rely on for 75 percent of our energy are simply running out * * *.
>
> Our Nation's economic and political independence is becoming increasingly vulnerable. Unless profound changes are made to lower oil consumption, we now believe that early in the 1980's the world will be demanding more oil than it can produce * * *.
>
> We will constantly live in fear of embargoes. We could endanger our freedom as a sovereign nation to act in foreign affairs. Within 10 years, we would not be able to import enough oil from any country, at any acceptable price * * *.
>
> Inflation will soar; production will go down; people will lose their jobs. Intense competition for oil will build up among nations and also among the different regions within our own country. This has already started.
>
> If we fail to act soon, we will face an economic, social, and political crisis that will threaten our free institutions.

Seven months later, the President warned again of the encroaching threat to national security if the rising dependence on foreign oil is not reversed soon.[2]

> If this trend continues, the excessive reliance on foreign oil could make the very security of our Nation increasingly dependent on uncertain energy supplies. Our national security depends on more than just our Armed Forces; it also rests on the strength of our economy, on our national will, and on the ability of the United States to carry out our foreign policy as a free and independent nation. America overseas is only as strong as America at home.
>
> The Secretary of Defense said recently, "The present deficiency of assured energy sources is the single surest threat * * * to our security and to that of our allies."

---

[1] The President's address to the Nation, Apr. 18, 1977, in Weekly Compilation of Presidential Documents Monday, Apr. 25, 1977, vol. 13, No. 17.

[2] The President's address to the Nation, Nov. 8, 1977, in Weekly Compilation of Presidential Documents, Monday, Nov. 14, 1977, vol. 13, No. 46.

STATEMENT BY THE SECRETARY OF DEFENSE

The Secretary of Defense elaborated this concern in his testimony before the House Ad Hoc Committee on Energy on May 4, 1977;[3]

> I do believe my present responsibilities as Secretary of Defense make me aware of the very substantial impact, in fact, the crucial nature, of the energy shortage and of the need for a U.S. program to redress it. In fact, there is no more serious threat to the long-term security of the United States and to its allies than that which stems from the growing deficiency of secure and assured energy resources * * *.
>
> The threat to national security, the economy and our way of life which arises from the energy crisis is not yet fully recognized by all. Some refuse to accept the fact that the energy crisis is real, and that its solution will require the development of a national policy and purpose commanding the dedication of the Nation, its resources, and its people over many years. Ultimately, the only alternative is disaster.
>
> We are all familiar with the continuing risk of oil supply interruptions and upward pressures on prices from politically motivated embargos such as we experienced 4 years ago. Much less attention has been given to the potential for a much more serious interruption of oil supply by hostile forces in time of war. In the event of some future confrontation, the Soviet Union might be able to restrict access of the Western World to its essential oil supplies to a degree of severity and duration greater than any embargo by the oil producers. The U.S.S.R. might attempt to deny access to the oil of the Persian Gulf by direct attack on the facilities of the major oil-loading ports, which lie near Soviet territory. Simultaneous action to interdict on the high seas tanker movement of oil from other exporting nations could vastly exacerbate the oil supply situation for the United States and its allies.
>
> The military, political, and economic risks of oil interruption are very real, and are steadily increasing as dependence on imported oil continues to grow * * *.
>
> There is a third and greater energy threat to the Nation which has until recently received all too little popular attention, but which, as the President has said, should be the foremost consideration in development of national energy policy. This third threat is neither military nor political. It is, quite simply, resource depletion. A finite world supply of oil and gas will soon repeat the cycle so long evident in the United States. Growth in producible reserves will slow, halt and then go into decline as the remaining proven undiscovered resources grow smaller and the rate of discovery diminishes in the face of steadily increasing demand. The annual expansion in worldwide production which has been the foundation of 20th century world economic growth will level off and begin to decline.
>
> Arguments that much greater hydrocarbon reserves remain to be discovered miss the point. A growing consumption rate assures that even if so they too will be quickly consumed * * *.
>
> I believe there is comparatively little time for the United States to respond to the President's call and move toward reducing its dependence on imported oil. Failure to do so will impose increasing risks to our national security in the next few years and lead inexorably to the collapse of the world oil supply/demand balance in the next decade. Should that occur the effects on the security and economic viability of this Nation and the free world will be catastrophic.

PRIMARY FEDERAL TASKS IN A NATIONAL SECURITY RESPONSE

Almost by definition and by law and precedent,[4] any program designed to cope with a serious threat to national security serves to legitimate a leading Federal role. This role involves several complementary activities:

---

[3] Hearings before the Ad Hoc Committee on Energy, U.S. House of Representatives, 95th Cong., 1st sess., on the National Energy Act. Hearings held on May 4, 5, and 12, 1977, pp. 69–72.

[4] Among general studies of earlier U.S. experience are: "The United States at War: Development and Administration of the War Program by the Federal Government"; prepared under the auspices of the Committee of Records of War Administration by the War Records Section, U.S. Bureau of the Budget, DeCapo Press, New York, 1972, 555 p. "Industrial Mobilization for War: History of the War Production Board and Predecessor Agencies, 1940:1945," vol. I, Program and Administration. Prepared by the Bureau of Demobilization, U.S. Civilian Production Administration, 1947, published by the U.S. Government Printing Office, 1009 pp. "Administrative Reflections from World War II," by Luther Gulick, University

PRIMARY EXECUTIVE RESPONSIBILITY

Previous experience has featured an executive branch with primary responsibility for shaping and launching the Nation's response, particularly to:

1. Identify the nature of the threat and design the response.
2. Set quantitative targets for industrial goods, manpower, production of additional munitions, fuels and other resources needed to offset or at least forestall the threat.
3. Direct large scale procurement of the goods and services needed;
4. Determine and award priority access to critical materials to serve production targets alined with national security goals, and restrict nonpriority uses when required.
5. Enlist and mobilize broad participation and support from State and local governments and the private sector as a whole;
6. Maintain the strength of the international collective security system.

THE SUPPORTING CONGRESSIONAL ROLE

The role of Congress in national security emergencies has been primarily one of authorizing and supporting executive initiatives, particularly to:

1. Authorize, where needed, the exercise of existing contingency emergency powers.
2. Enact additional tax, loan guarantees and investment write offs designed to accelerate industrial plant conversion and to offset wartime risks.
3. Appropriate additional funds as required to pay for federally procured goods and services or other programs to meet the goals;
4. Supplement executive policy and program initiatives with congressional proposals developed independently if executive programs appear to be inadequate.

The wartime experiences, including the prewar periods of preparation, from which these generalized precedents have been drawn are not directly comparable, even with each other: World War II involved much more widespread controls and more complete mobilization and conversion to war production of the national industrial base than did the Korean or the Vietnam wars.

In all instances, however, large-scale, direct Federal procurement of goods and services, in pursuit of production goals alined with national security objectives, provided the primary Federal management tool by which such national production goals could be both established and achieved.

NATIONAL ENERGY PRINCIPLES IN THE CONTEXT OF A NATIONAL SECURITY RESPONSE

The President presented 10 fundamental principles as the underlying rationale for the national energy plan and the framework within which present and future policies must be formulated.[5]

---

of Alabama Press, 1948, 139 p. Industrial production experience during World War II and the Korean War was reviewed and analyzed in "Materials Shortages. Selected Readings on Energy Self Sufficiency and the Controlled Materials Plan." Prepared by CRS for the permanent Subcommittee on Investigations of the Committee on Government Operations. U.S. Senate. Committee print, August 1974, 256 p. and "Workshop on Resource Management," Committee print, report published by the same Senate committee, February 1975, 76 p.

[5] The National Energy Plan, pp. 25–32.

THE 10 PRINCIPLES

In summary, the 10 principles are:

(1) The energy problem can be effectively addressed only by a government that accepts responsibility for dealing with it comprehensively and by a public that understands its seriousness and is ready to make necessary sacrifices.

(2) Healthy economic growth must continue.

(3) National policies for the protection of the environment must be maintained.

(4) The United States must reduce its vulnerability to potentially devastating supply interruptions.

(5) The program must be fair. The United States must solve its energy problems in a manner that is equitable to all regions, sectors, and income groups.

(6) The cornerstone of national energy policy is that the growth of energy demand must be restrained through conservation and improved energy efficiency.

(7) Energy prices should generally reflect the true replacement cost of energy.

(8) Both energy producers and consumers are entitled to reasonable certainty as to Government policy.

(9) Resources in plentiful supply must be used more widely and the Nation must begin the process of moderating its use of those in short supply.

(10) The use of nonconventional sources of energy—such as solar, wind, biomass, geothermal—must be vigorously expanded.

There has been very little public disagreement with these principles. Although the plan's goals and accompanying programs and policies have been assessed in depth in a wide range of official and unofficial studies,[6] the principles themselves have received relatively little analysis and attention.

t may be useful to review the underlying rationale reflected in the principles to determine whether they reflect the national security dimensions and urgency of the energy problem which the President and the Secretary of Defense have publicly described.

The first, sixth, and seventh of the principles laid down in the national energy plan arguably do not.

THE FEDERAL ROLE

The national energy plan describes the Federal role as follows:

> The first principle is that the energy problem can be effectively addressed only by a Government that accepts responsibility for dealing with it comprehensively, and by a public that understands its seriousness and is ready to make necessary sacrifices. The declining availability of oil and natural gas will affect virtually all energy prices and consumption patterns in the United States, for the various energy supplies are all part of an integrated energy market. Therefore, in this democratic society, a solution can be found only in comprehensive Government policymaking informed by public comment and supported by public understanding and action.
>
> The Federal Government can pass laws and encourage action. State and local governments can play active roles. But this society can function at its best only when citizens voluntarily work together toward a commonly accepted goal. Washington can and must lead, but the Nation's real energy policy will be made in every city, town, and village in the country.

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[6] See annex I for a list of these studies and summary report on the oil import savings assessments.

Comment

The fact that "declining availability of oil and natural gas will affect virtually all energy prices and patterns of consumption in the United States" may not be considered a self-evident reason for "comprehensive Government policymaking." A substantial congressional and public constituency has argued the opposite case, namely, that to remove current Government price and other regulatory controls on oil and natural gas would enable the economy as a whole to adjust to a new "integrated energy market" with consumption patterns much more efficiently geared to the realities of declining oil and natural gas supplies, as prices rise to meet near-term replacement costs measured by or against the price of imported oil.

If, however, the rationale can be persuasively recast so as to reflect the threat to national and free world security, as the energy problem is elsewhere defined by the President, the assertion of a Federal policymaking role would presumably be far less objectionable to the public.

The rationale could be rephrased along these lines:

> The first principle is that the energy problem can be effectively addressed only by a Government that accepts responsibility for dealing with it comprehensively, and by a public that understands its seriousness, and is ready to make necessary sacrifices.
>
> The declining availability of oil and the increasing dependence of the United States and the free world on oil imports whose availability in volume sufficient to meet world demand cannot be assured presents an unacceptable risk to national and free world security. Therefore, a solution should be found in comprehensive executive and congressional leadership, informed by public comment, and supported by public and private understanding and action.

THE ROLE OF CONSERVATION AND PRODUCTION

Further possible incongruity between the problem and the principles as defined is revealed in the sixth principle of the plan, which sets forth the rationale for a dominant conservation role:

> The sixth principle, and the cornerstone of national energy policy, is that the growth of energy demand must be restrained through conservation and improved energy efficiency. Conservation and improvement in energy efficiency is the most practical course of action for the United States and for the nations of the world. Conservation is cheaper than production of new energy supplies, and is the most effective means for protection of the environment.

Comment

As stated, this principle—as well as the complementary 9th and 10th principles calling for switching from oil to use of plentiful fuels and renewable resources—fails adequately to suggest the massive production effort on the other side of the demand–supply equation, which must be accomplished within a very short period of time.[7] To do this will require large-scale replacement of existing petroleum-fueled capital stock with new equipment using other fuels, or large-scale construction of synthetic oil production capacity using domestic raw materials or some combination of these. This, in turn, would require very substantial production efforts which, under the national security emergency thesis, would need to be accelerated to virtually wartime production rates.

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[7] This point is made in, among others, the GAO, CRS, OTA and University of Texas staff assessments of the plan. See annex I for citations to these and other studies of the plan.

Production of insulation is already insufficient to meet current demand. The manufacture of heat pumps and cogeneration facilities requires expanded production capacity that will need fuels and energy. When the fuel switching goals are added, the volume of production of new and improved energy-using equipment contemplated is formidable: Fluidized bed combustors, scrubbers, and other facilities to prevent environmental damage, a wide variety of solar-collecting and solar-using hardware, recycling equipment, solid waste conversion plants, methane and methanol and ethane and ethanol production systems, electric cars, batteries and recharging units. Production of these kinds of industrial equipment must be in addition to the massive production effort implied in the plan's fuel balance tables to increase domestic supplies of nuclear energy, from 1976 levels of 1.0 MMb/doe to 3.8 MMb/doe; coal, from 7.9 MMb/doe to 14.6 MMb/doe; and domestic oil, from 9.7 MMb/d to 10.6 MMb/d.

To repeat, reduction of oil import dependence will not take place as a result of belt tightening alone; a major production effort will be required to produce the products which use non-petroleum-based fuels alternative to oil and use all fuels more efficiently.

The language used in the plan's statement of this principle, comparing the costs of conservation to production of new energy supplies,[8] suggests a failure to identify the fact that the financial problems confronted by energy *users*, on whose individual decisions the plan heavily relies, are very different from those of oil and natural gas *producers*.

Oil and natural gas producers have traditionally financed new investment out of current cash flows, rather than through borrowing. Few energy end-users, small or large, residential or industrial, enjoy such luxury. Most must borrow at commercial rates.

Furthermore, oil and gas producers have a guaranteed market for their products for a long time to come, and can reasonably expect that profits will not diminish in the near future. Industrial energy users called upon to switch from oil and gas to alternative fuels when there may still be 10 or more years of economical and productive use in existing boiler or generating plant risk losing competitive markets for their products if the full cost of the added capital plant replacement is passed on the the consumer, or taking a substantial cut in profits if it is not. Even greater risks face the individual householder whose available cash and credit may already be stretched to the limit.

The continued sluggishness in the U.S. and free world economies discourages bold private investments now for a future postpetroleum age.

The sixth principle could be enlarged to reflect the reality that a massive industrial and energy production effort will be needed even to achieve the plan's own quantitative goals [9] and that Federal procurement of industrial goods enabling large-scale conversion to fuels other than oil may be needed to meet the goals within the time frame of 1985. That principle might be restated:

> The cornerstone of national energy policy is that the nation's dependence on imported oil must be reduced through accelerated programs to achieve conservation and improved efficiencies of energy use concurrent with a major energy and industrial production effort to permit the necessary switching to fuels other than

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[8] i.e. "Conservation is cheaper than production of new energy supplies."

[9] These goals are listed on p. 13 below.

conventional oil and natural gas, without damage to the environment. Federal procurement contracts should be used to accelerate and expand the capital plant production and conversion efforts needed in the private sector to meet the Plan's quantitative goals.

ENERGY PRICING CONCEPTS

Similarly, the seventh principle, which sets the basic framework for the plan's energy pricing policies, appears to suggest that the size and pace of national production and conversion effort designed to deal with threats to national security should be left primarily to individual and collective market choice:

> The seventh principle underlying the national energy plan is that energy prices should generally reflect the true replacement cost of energy. Energy prices should move toward a level that reflects the true value of energy in order for market signals to work in harmony with conservation policy. When the cost of expensive foreign oil is averaged with cheaper domestic oil, consumers overuse oil. Government policy that promotes overuse by artificially holding down prices misleads consumers into believing that they can continue to obtain additional quantities of oil at less than its replacement cost.
>
> Artificially low prices for particular energy sources also distort interfuel competition. The artificially low price of natural gas, for example, has encouraged its use by industry and electric utilities, which could use coal, and has made gas unavailable for new households, which could make better use of its premium qualities.
>
> Neither Government policy nor market incentives can create additional oil or gas in the ground. But from a long-term perspective, prices are an important influence on production and use. As long as energy consumers are enticed into believing that they can continue to pay yesterday's prices for tomorrow's energy, they will continue to use more energy than the Nation can really afford, U.S. resources will be rapidly exhausted, and continued overuse will make the inevitable transition more sudden and difficult.
>
> Although producers need incentives for exploration and new development, pricing policies should not give them windfall profits unrelated to their economic contribution. If producers were to receive tomorrow's prices for yesterday's discoveries, there would be an inequitable transfer of income from the American people to the oil and gas producers, and producers' profits would be excessive.

Comment

This pricing approach does not appear consistent with the President's placement of the national energy problem in the context of grave impending danger to United States and free world security, and with the fact that the presidentially projected period of time to prepare for and surmount—or at least forestall—the threat is limited.

It is generally accepted that in times of national emergency or threat to security, Government intervention in the market to preempt and redirect resources to meet the emergency or danger is justified.

Under these circumstances, existing pricing concepts are likely to be superseded by other pricing arrangements adapted to the particular emergency. In some instances, this may involve strict price controls over either the whole economy or, on a more selective basis, over materials and products in short supply, in order to control inflation. Emergencies are also likely to involve expanded Government procurement of necessary equipment, materials, or services in which the negotiated price may, for example, include a premium to offset financial risk or be calculated on a cost-plus-fixed-fee basis.

Additional subsidies or other incentives have also been made available for emergency situations, such as war risk insurance, extraordinary grants or loans for construction of new or expanded industrial plants including, where necessary, construction of plants to produce capital equipment in support of an expanded industrial base.

Nor has Government intervention designed specifically to distort market pricing in the public interest been limited to emergency conditions. For 50 years, the United States followed a *de facto* national energy policy that deliberately chose to subsidize private producers to produce oil and natural gas, with the objective of providing expanding energy supplies at the lowest possible cost consistent with reliability of supply. The policy served the United States' domestic social goals for many years. It enhanced personal mobility and economic choice to an extent that would otherwise have been unattainable in an area as vast as this continent and, through the secondhand car market, enabled a qualitative "redistribution of wealth" which has been envied even in more centrally planned economies.

The Federal Government may decide that subsidies on an equivalent or greater scale may be required if the use of unconventional sources of energy is, as intended by the plan, to be "vigorously expanded." [10]

If revised and expanded to include a pricing option which discriminates in favor of renewable and recycled fuels so as to rapidly expand their availability and use, the rationale for future energy and investment pricing principles might be phrased along these lines:

> The pricing and investment principles underlying the National Energy Plan include the concept that the prices for oil and natural gas, as for their more abundant but nonrenewable substitutes of coal and uranium, should generally reflect the replacement cost of imported oil.
>
> The subsidies provided for investment in equipment to manufacture or use renewable and recycled fuels, however, should generally reflect within 5 years the full replacement cost of capital needed for these tasks. This should apply to individual users who made such investments and to industrial users and producers of such equipment alike.
>
> Energy users of renewable and other fuels alternative to oil ought to be given incentives equivalent in scope and value to those which were given to producers to explore and develop oil.

With or without generous tax and other business subsidies reflecting privately assumed risks of wartime proportions, large scale Federal procurement may be needed to underwrite an expanded private industrial production capability and to guarantee a continuing market for the new fuel conservation and fuel conversion equipment and facilities needed to make the transition to a less oil dependent age.

During World War II and the Korean war, substantial Federal intervention and redirection of private industrial production to meet national security production goals was accepted in large measure because it was conceived of as essentially temporary, "for the duration." There was general agreement on the wartime goals—defense of democracy, defeat of its foes—but there was also general agreement that, with victory, national production would revert to private hands, its output again determined by civilian consumption choices and needs.

Clearly, a direct analogy cannot be drawn with the present situation. "Victory" will not be "won" by 1985: achievement of the plan's 1985 energy goals would still leave the United States depending on annual imports of about 6 million barrels of oil a day even if these goals could be met—and most analysts conclude that they cannot. (See annex I.) However, the accelerated Federal procurement program explored in this paper as an option would not be needed after 1985. Under the assumptions stated in this paper, accelerated replacement of federally owned oil-using capital stock would have been largely achieved by 1985, and thus Federal procurement contracts could then revert to normal annual replacement levels.

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[10] National Energy Plan, p. ix, 31-2 and 75-81.

The program could be designed such that, by then, demand in the private sector could and would be expected to drive the process of expanding the volume and scope of the Nation's conversion to the use of fuels other than oil.

A NATIONAL SECURITY ORIENTATION FOR THE NATIONAL ENERGY PLAN

What specific executive and legislative measures could be undertaken more rapidly to convert the Nation's stock of capital plant and equipment by 1985 and to mobilize its industrial productive capacity to meet the national security dangers addressed by the national energy plan?

EXECUTIVE MEASURES

The President and his advisers have already undertaken the first two of the tasks historically assumed by the Executive in situations presenting foreseeable dangers to national security, and many of the rest can be undertaken within the framework of the annual Federal budgets and under existing powers.

Define the nature of the threat to security

The President has identified the nature of the threat and designed a response, in the form of the national energy plan, and the proposed National Energy Act.

Set quantitative targets

The President has set quantitative targets, to be accomplished over a period of about 8 years, intended to meet three "overriding" energy objectives:

1. As an immediate objective that will become even more important in the future, to reduce dependence on foreign oil and vulnerability to supply interruptions;
2. In the medium term, to keep U.S. [oil] imports sufficiently low to weather the period when world oil production approaches its capacity limitations; and
3. In the long term, to have renewable and essentially inexhaustible sources of energy for sustained economic growth.[11]

Among the specific quantitative goals identified in the plan are the following intended to be achieved by 1985:[12]

4. Establish a Strategic Petroleum Reserve of 1 billion barrels;
5. Reduce gasoline consumption by 10 percent below the 1976 level (6.3 million b/d as compared with the 1976 consumption rate of 7 million b/d);
6. Increase coal production from 1976 output of about 600 million tons to more than 1 billion tons annually, anticipating

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[11] National Energy Plan, Overview, p. xi.
[12] Ibid., pp. 83–4 and ff.

substitution of coal for oil or natural gas equivalent to 2.2 million b/doe for industrial uses and 1.1 million b/doe for utilities.[13]

7. Insulate 90 percent of the approximately 74 million existing residential units and all new buildings;
8. Install solar energy units in more than 2½ million homes;
9. Limit U.S. oil imports to 5.8 million b/d by 1985.

Place orders for large scale Federal procurement of goods and services

Except for purchases for the Strategic Petroleum Reserves, Federal procurement has not yet been employed on any significant scale to underwrite the capital plant conversion and production efforts required to achieve the quantitative goals of the plan.

The opportunities and authorities for an accelerated exercise of this power exist, however, and could, for example, be used in the following ways:

Synthetic fuels.—Long-term Federal contracts for procurement of oil from shale or other synthetic fuels for Department of Defense uses and stockpiling in the Strategic Petroleum Reserves could be negotiated on a cost basis. Pilot tests using synthetic fuels from coal, shale oil and tar sands have already been conducted under DOD-ERDA financing. DOD consumption of petroleum was 173 million barrels in 1976—about 450,000 barrels per day.

"Gasahol".—Federal multiyear contracts for purchase of various forms of nonpetroleum substitutes for gasoline and a Federal commitment to use such substitutes for at least 10 percent of gasoline consumed in federally owned vehicles could be used to guarantee a private sector industrial production capability for these fuels. This would amount to annual purchases of 1.6 million gallons of gasoline substitutes, at 1976 consumption levels.

Electric or other non-gasoline-using vehicles.—As of mid-1976, the Federal Government owned 425,226 motor vehicles, operated at an annual cost of $664.5 million (including depreciation) and using the equivalent of 16 million barrels of oil a year.[14] Excluding buses and ambulances, the Federal Government acquired 19,155 vehicles and disposed of 14,014 in 1976. Public Law 94–163, the Electric and Hybrid Vehicle Research Act, mandates Federal purchase or lease of 2,500 electric or hybrid vehicles by mid-1978 and an additional 5,000 by April, 1981, subject to certain conditions. It also calls for introduction of electric and hybrid vehicles into Federal fleets, including the U.S. Postal Service, GSA, DOD, and other agencies "as soon as possible." Incremental costs, as required, including differential operating costs may be underwritten by the ERDA budget. Accelerated and additional purchases would be possible through the annual Federal budget authorization and appropriation process.

Photovoltaic electric power generating panels, also federally procured, could be installed at Federal facilities or at gasoline stations serving Federal fleets, as supplementary battery recharging services for electric vehicles.

Solar heating and cooling and photovoltaic energy systems.— Programs included in the National Energy Act, as tentatively agreed to by both House and Senate conferees, call for installation of solar heating and cooling in about 3,000 Federal buildings in 3 years, at a cost of $100 million, and installation of up to 30 megawatts of photovoltaic energy systems, at a cost of $98 million over 3 years. Both Federal purchase programs were intended to accelerate the commercialization of solar energy and, in the case of photovoltaics, to

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[13] Data on anticipated substitution provided in Hearings before the Ad Hoc Committee on Energy, on the NEA, op. cit., Administration testimony and tables, pp. 210–11, submitted in response to questions by Congressman John Dingell, May 12, 1977.

[14] Federal leased vehicles are not included in this total.

> temporarily create, through Government procurement, a large enough market for solar cells so that mass production techniques will be instituted in their manufacture, thus driving down the cost of the cells and consequently stimulating a higher private demand for the solar cells.[15]

Since the Federal Government owns over 400,000 buildings, additional Federal procurement could be used to purchase and install such equipment in many thousands more buildings to expand more rapidly the industrial production capacity of the private sector and to standardize prices and performance criteria for these products. If final action on the National Energy Act is delayed, Federal procurement can be authorized and funded through the annual Federal departmental authorization and appropriations process.

Other Federal procurement orders.—Federal procurement contracts could also be employed to enlarge and underwrite the market for waste recycling, cogeneration systems, wind energy conversion systems environmental protection equipment, fluidized bed combustion devices, and other equipment needed to convert Federal industrial and electric power generating plants from the use of oil and gas to coal, installing them in all facilities now operated by the Federal Government, including the Department of Defense, ERDA laboratories, and the major Federal power administrations—Bonneville, Alaska, Southwestern, and Southeastern.

In a report, "Estimate of National Hydroelectric Power Potential at Existing Dams," published July 20, 1977, the U.S. Army Corps of Engineers concluded that the development of all hydropower potential at existing dams could generate 160 billion Kwh of electricity and save 727,000 barrels of oil per day. Only 5,500 of the 49,500 dams in the United States are owned and operated by the Federal Government. Under a national security rationale, the Federal Government could elect the option of assuming the full capital cost of developing the maximum potential in all other dams as well, whether publicly or privately owned, in order to accelerate the availability of this additional supply.

Determine priority access to critical materials and restrict uses when required by national security

Under the Defense Materials System and the Defense Priorities System, the Department of Commerce and the General Services Administration have authority, delegated by the President, to allocate scarce material for production of items deemed essential for national security. This is done under procedures first adopted in World War II, subsequently authorized under the Defense Production Act of 1950, as amended, recently extended through September 30, 1979 by, Public Law 95–37.

These authorities have been invoked for production of equipment needed for the Alaska Pipeline and could be invoked, if needed, for expanded production of capital goods and equipment using renewable and other fuels alternative to oil, such as those suggested in the previous section.

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[15] Report of the Committee on Energy and Natural Resources, U.S. Senate, on S. 2057, National Energy Conservation Policy Act, S. Rept. 95–409, August 1977, p. 66.

The President also has authority under section 232 of the Trade Expansion Act of 1962, as amended, to limit imports of any commodity upon a finding that such limitation is required to prevent impairment of national security.

In a recent decision involving imposition of oil import fees, the Supreme Court ruled that the President's authority to limit imports for national security reasons included the authority to do so by means of license fees and was not limited to the use of quantitative methods such as quotas.[16]

The President's power to redirect energy uses by quantitative limitation is augmented by powers enacted in EPCA (Public Law 94–163, Section 457) which authorize him to impose direct controls on refinery operations to adjust the proportions of residual fuel oil, gasoline, or any other refined petroleum product if he determines such adjustment is necessary to provide for public health, safety and welfare, and the national defense.

Enlist and mobilize broad public and private sector participation and support

During World War II and the Korean War, a significant component of the high level of popular support for the national defense effort derived from the enlistment of private sector participation in the production planning process, as well as in the production effort.

Although production goals and priorities were set by the executive branch, the pace of production was determined by private industry. The planning procedures and accelerated production pace depended on close consultation and continuing detailed exchange of information on materials requirements and progress of the industrial production efforts at all levels and stages. This close mutual involvement in the planning process helped to produce a sense of national partnership that tended to transcend contractual relationships.

Large-scale Federal procurement in support of quantitative energy goals could also help to mobilize popular participation and support for a national energy plan cast in national security terms. Negotiations on the terms and scheduling of substantial contracts for the production of synthetic fuels and equipment using non-petroleum-based fuels provide both the ends and the means for direct enlistment of the private sector in broader participation in planning for and achieving these national energy goals.

A national industrial production program geared to the achievement of accepted energy goals provides a valid base for national or local campaigns to sell energy production or fuel conversion bonds and stamps to mobilize both extra capital and popular support.

The public market represented by Federal procurement could be substantially broadened by Presidential enlistment of State Governors and county and municipal executives in a similar expanded procurement effort to convert State and local capital plant and equipment in publicly owned and financed facilities and services to renewable and other fuels other than oil.

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[16] *Algonquin SNG* vs. *FEA*, U.S. Supreme Court Docket No. 75-382, June 17, 1976. See also Cabinet Task Force on Oil Import Control. The Oil Import Question: A Report of the Relationships of Oil Imports to the National Security, GPO, February 1970. pp. 2-7, and 19-55.

The overall size and mix of a public market for synthetic fuels, vehicles fueled by alternatives to oil, solar equipment, waste conversion and recycling plants, efficient coal using combustors and environment protection devices, district heating and cogenerating facilities, depends on projected demand. Contracts to meet this demand will require consultation and mutual cooperation between the Federal Government and State and local governments, between the public purchaser and the private producers.

Large-scale Federal procurement orders can provide a clear and unambiguous evidence of Federal commitment to the declared national security energy goals. The planning, contract negotiation, and production processes themselves could be a means, once more, by which a nation and its citizens can be convinced of the seriousness of the threat to national security created by our present dependence on imported oil and, having been convinced, mobilized in its defense.

Maintain the strength of the international collective security system

A threat to national security is by definition a danger that, if not resolved or forestalled, threatens either war or sufficiently massive political or economic disruption that our antagonists need not resort to war to achieve their aims.

It is the latter danger which the President foresees as facing the United States and its industrial allies and seeks to forestall sufficiently to:

> Weather the period when world oil production approaches its capacity limitation; and in the long term to have renewable and essentially inexhaustible sources of energy for sustained economic growth.[17]

The United States presently depends on oil for 47 percent of its total energy needs and is now importing nearly half of all oil consumed in this country. Other industrial democracies are still more vulnerable to supply interruptions: Western Europe depends on oil for 63 percent of its total domestic energy consumption, and imports 97 percent of that oil. Japan is 80 percent dependent on oil and imports all of it.

The volume of physical capital stock of oil-fueled vehicles, heating and cooling systems, industrial boilers, and generating plants which these proportions represent is gigantic. Much of this stock—for Europe and Japan as well as the United States—still has 10 years or more of usefulness. Much of this capital stock must be replaced much earlier by equipment and facilities using fuels other than oil if the security goal of reduced dependence on imported oil is to be achieved by the mid-eighties.

The collective security arrangements which have served to prevent the outbreak of global war have been successful because they were backed by, and negotiated from, a position of military, industrial, and economic strength. A critical element of that strength was the prompt supply of military and industrial goods and equipment transferred in large volume, by aid and trade, to the members of the North Atlantic Alliance by the United States, acting as the "arsenal for democracy."

As the President and the Secretary of Defense pointed out in their testimony, our continued and increasing dependence on imported oil is weakening that industrial and economic stength and is making our military defense increasingly vulnerable as well, placing the whole postwar structure of international security at risk.

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[17] See p. 13 infra.

Achievement of the U.S. energy goals as stated by President Carter would undoubtedly play a major role in reducing U.S. vulnerability to interruptions in oil import supply but these goals may still leave U.S. allies exposed to unacceptable risks. U.S. security interests may require further expansion of U.S. industrial production capacity and delivery of an additional substantial volume of equipment using non-petroleum-based fuels to enable substantial replacement of our allies' oil-using capital stock earlier than would otherwise occur.

Federal procurement and delivery of such items can be done within the framework of existing collective security agreements and assistance programs. There is also historical precedent for assistance to NATO allies to increase their industrial capacity for equipment essential to collective security and free world strength. During the 1950's, U.S. assistance was provided for a joint military production program financing additional production capacity based in Europe for designated equipment. A similar joint program could be undertaken to accelerate production and use of equipment and facilities using fuels alternatives to oil.

LEGISLATIVE MEASURES

Historically, legislative measures enacted during periods of national security or wartime emergencies have served primarily to support Presidential initiatives and decisions with such additional tax and other authorizations and appropriations as were considered necessary. Any or all of the executive measures outlined in the preceding section could be launched by the President under authorities enacted in laws still in force. Legislative measures could be limited to no more than those required to fulfill such procedures as may be needed to authorize the exercise of some emergency powers,[18] to enact additional tax and other fiscal measures to raise revenues, and to appropriate funds as required to pay for federally procured goods and services or other programs administered by executive departments to meet national energy goals.

However, Congress has the major option of taking much stronger initiatives independently or supplementing executive initiatives in dealing with situations involving risk to national security.

The energy record of the 93d and 94th Congresses, and during the first session of the 95th Congress, provides concrete evidence that the legislative measures Congress may choose to enact by no means constitute passive endorsement of the energy initiatives of three Presidents who have urged early approval of their proposals.

Congress retains, and may wish to exercise, the option to assume a much stronger leading role in the design and rationale of new national policies intended to reduce U.S. dependence on imported oil, and independently to promote Federal procurement and other oil import saving programs which could advance this national security goal.

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[18] For example, although the President is ordered under EPCA to design and issue regulations for a contingency plan for gasoline rationing, additional formal congressional concurrence is needed before the President may order such a plan to be put into effect (Public Law 94-163, Section 201(c)).

FEDERAL PROCUREMENT OPPORTUNITIES FOR INCREASING PRIVATE SECTOR INDUSTRIAL PRODUCTION CAPACITY FOR SELECTED OIL-SAVING PRODUCTS

Oil-saving product	Potential Federal market	Potential oil savings
Synthetic oil (oil shale, from coal)	Annual Department of Defense use equals c. 180,000,000 bbl of petroleum (estimated, fiscal year 1978).	Up to 500,000 bbl of oil per day or 180,000,000 bbl of oil per year.
Electric or other non-gasoline-using vehicles.	Federal fleet (worldwide in 1976) equals 425,000 vehicles. Annual new vehicle purchases equals c. 20,000 vehicles.	Depends on degree of replacement of existing fleet: e.g., at 50 percent replacement equals 8,000,000 bbl of oil per year or c. 22,000 bbl of oil per day.
"Gasahol" (ethanol, methanol)	Annual gasoline use by Federal fleet equals 16,000,000 bbl of oil equivalent per year.	Depends on degree of substitution for fuel in remaining gasoline-using cars; e.g., at 20 percent equals 1,600,000 bbl of oil per year.
Photovoltaic and wind energy conversion systems.	400,000 federally owned buildings	Depends on degree of substitution; e.g., photovoltaic devices and solar hot water heaters could be installed in all 400,000 federally owned buildings.
Solar hot water and heating	In 1977, Federal buildings and facilities used 36,600,000 MWh of electricity and 22,000,000 bbl of fuel oil.	
Products which enable oil savings in industrial plants and utilities which burn oil (fluidized bed combustors, environmental protection equipment, cogeneration, district heating equipment, and waste-to-fuel equipment).	Not available at time of writing. DOD has about 55 large boiler plants in the United States which could be converted to coal.	Not available at time of writing.
Incremental hydroelectric power: Turbines and generators.	Federal Government owns only 5,500 of the 49,500 dams in the United States. If Federal procurement were employed to develop all the hydro potential of these 49,500 dams, additional power generated is estimated at about 160,000,000,000 kWh of electricity which equals 727,000 bbl of oil per day.	

ANNEX I.—NATIONAL ENERGY PLAN: OVERVIEW OF THE PRESIDENT'S PROPOSALS—ISSUE BRIEF NO. IB77060

(By Frances A. Gulick, Environment and Natural Resources Policy Division)

[Excerpts]

PRELIMINARY ASSESSMENTS OF THE IMPACT OF THE PLAN ON THE OIL IMPORT SAVINGS GOALS

Four congressional agencies—the Congressional Budget Office (CBO), the Congressional Research Service (CRS), the General Accounting Office (GAO), and the Office of Technology Assessment (OTA)—have completed preliminary assessments of the President's proposed National Energy Plan, in response to requests from Committees and Members engaged in marking up the Administration's omnibus bills, H.R. 6831 and S. 1469. All of these are agreed, with minor differences, that the direct and indirect price and other economic impacts of the Plan itself would not produce results very different from what might take place without the Plan, with oil product price increases of between 7 to 12 cents a gallon believed likely (not counting the impact of the Administration's proposed gasoline tax, a measure dropped in the House).

All of these assessments, however, also conclude that the Plan, even if enacted as proposed, could not produce the quantitative oil savings effects targeted in the Plan's goals because of shortfalls which would occur in virtually all other quantitative goals.

CONGRESSIONAL BUDGET OFFICE

The CBO report, issued May 31, 1977, concluded that anticipated oil savings will reach only 3.6 million barrels a day, rather than the Administration's estimated 4.5 mb/d. About 0.6 of the 0.9 mb/d discrepancy, according to CBO calculations, results from lower estimates of coal conversion potential. The remaining 0.3 mb/d discrepancy is due to differing estimates of impact of home insulation and solar equipment tax credits.

THE CONGRESSIONAL RESEARCH SERVICE

Although no specific quantitative shortfall is provided, the initial CRS assessment, issued June 1, 1977, concluded that the Plan's estimated import savings are "optimistic and not likely to be achieved." Although imports probably will be higher than 7 mb/d, CRS analysts do not expect imports to exceed a ceiling of 12 mb/d, even without the Plan, because of other constraints.

A subsequent CRS report on "The Carter Coal Conversion Program," issued June 10, 1977, concluded that the 5.1 percent per year growth rate of energy input to industry forecast by the Plan from 1977 to 1985 is far too high. Based on historical performance of the U.S. economy since 1960, the rate would be closer to 3.1 percent, even subtracting recession-caused decreases, and would be further decreased by the effects of the Plan, as the Administration has since conceded. Furthermore, costs assumed in the Administration's calculations—estimated at $6.4 million for a 25 megawatt boiler plus $1.9 million for a scrubber—differ markedly from a number of other industry estimates, such as those presented in testimony to the Texas Industrial Commission in January 1977 (about $10 million without scrubber) and estimates made by the American Boiler Manufacturers Association (that scrubbing investment for a 25 megawatt boiler would be about $5 million rather than $1.9 million). The CRS report concludes:

"In sum, the Plan claims an increased coal use in industry of about 200 million tons in 1985. The concerns raised in this paper call into question some 140 million of these tons, 120 million tons of which result from an improbably high estimate of rate of growth of energy demand and the rest as the result of unreasonably low Plan estimates of the cost of coal-burning equipment."

GENERAL ACCOUNTING OFFICE

In a preliminary review of the Plan released on June 8, 1977, the GAO strongly criticized the Administration for proposing a Plan which could not meet its own goals, and concluded that further shortfalls would occur:

"We generally agree with these goals and believe that they can form the basis for developing a national energy policy between now and 1985. On the basis of our prior work, we believe that there is a serious energy problem and that the goals proposed by the National Energy Plan provide a useful way to address this problem. One fact that has not been widely recognized. however, is that the Administration did not design its Energy Plan to achieve the stated goals without unspecified voluntary actions or further mandatory actions not specifically identified except by example. Based on the Administration's own estimates, with a few exceptions, the plan will fall short of the goals—even if the Plan is fully implemented."

The GAO cited the following goals and administration estimates as evidence for this internal Plan discrepancy:

ADMINISTRATION'S PROPOSED ENERGY GOALS FOR 1985	ADMINISTRATION'S ESTIMATE OF WHAT THE PLAN CAN ACCOMPLISH THROUGH 1985
Reduce total energy growth to below 2 percent/year.	Reduction to 2.2 percent.
Reduce oil imports below 6 million barrels/day.	Reduction to 7 million barrels/day.
Insulate 90 percent of all buildings.	Insulate approximately 60 percent.
Use solar energy in 2.5 million homes.	Use solar energy in 1.3 million homes.

The report concluded:

"We believe that it is somewhat incongruous to ask the Congress to establish a set of National Energy Goals, and then propose a National Energy Plan that is not expected to achieve them. . . .

"Since under the best of circumstances, plans designed to meet goals often fall short, we believe that the plan should be redesigned to provide a reasonable opportunity of achieving the stated goals."

In its final version, issued July 25, 1977, the GAO concluded that the Administration's estimates for domestic energy supplies were overstated by a total of 3.9 mb/doe (of which coal shortfalls account for 2.3 mb/doe; natural gas, 1.0 mb/doe; and nuclear power, 0.6 mb/doe.) Consequently, the GAO believes oil imports would more likely be about 10.3 mb/d in 1985.

In a subsequent letter report issued October 14, the GAO released additional analysis of anticipated domestic oil production, concluding that crude oil production in the U.S. is more likely to be in the range of 8 to 9 mb/doe, rather than 10.6 mb/doe as the Administration has estimated: "This means that oil imports are more likely to be in the range of 12–13 mb/d instead of the 6 mb/d which is the Administration's goal."

OFFICE OF TECHNOLOGY ASSESSMENT

OTA (in prepublication draft analysis released June 24, 1977, and a final report issued August 1977) also has concluded that although the Plan is a major move in the right direction, the levels of supply projected by the Plan represent the upper limits of capacity and supplies of all fuels are likely to fall below the Plan's goals.

Two assessments of the degree of shortfall are contained in the report, one by a Task Force on Energy Supply, which attributes the shortages to a wide variety of probable logistical and regulatory delays, another by the OTA staff using 1950–1976 historical trends in energy supply and demand. The Task Force concluded that shortfalls of between 5.0 to 6.0 mb/doe would occur with shortages in oil and natural gas totalling between 2.0 and 3.0 mb/doe, as much as 2.4 mb/doe in coal, and 0.6 mb/doe in nuclear energy. These would be offset, however, by reduced coal demand about 2.4 mb/doe lower than the Administration estimates, leaving a net shortfall of 3.6 mb/doe. The OTA staff concluded that the gap between U.S. energy demand and domestic supply would widen to 16.5 mb/doe if the historical trends in demand (averaging 3% per year) do not change and if aggregate domestic energy production does not increase faster than historic trends indicate it will. The OTA staff report stated:

"The 'historic trends' analysis suggests that international shortages and price rationing are inevitable if United States oil import demands are not reduced. The basic question appears not to be whether the economy can continue to grow under more stringent conservation policies but whether conservation measures can take hold fast enough to head off the crippling impact of abrupt oil shortages in 1985."

OTHER ASSESSMENTS

Dr. Hans Landsberg, economist and senior fellow at Resources for the Future, in a mid-May review of the Plan's fuel balances (Plan, p. 96) also pointed out that these projections revealed projected results significantly at variance with the Plan's quantitative goals: Energy demand, according to the figures provided in the fuel balance tables, would grow at an average annual rate of 2.5 percent not 2 percent. He considered coal conversion and nuclear power additions to be overestimated due to foreseeable logistical difficulties, by as much as 3 mb/doe and concluded that the nation will need, in the absence of drastic mandatory conservation and conversion measures, "3.5 to 4 million barrels per day of oil above and beyond the target, or total 1985 oil import volume of 10.5 to 11 million barrels—if we are lucky, that is."

Another study, representing the "independent and individual evaluations" of some of the members of the faculty and staff of the University of Texas at Austin, issued May 11, 1977, places the oil import gap at 4.2 mb/d by 1985, primarily because production of oil, natural gas, and nuclear energy will be less than the Plan's balance sheet projections because of constraints (mainly price, according to these analysts) built into the Plan. Oil imports are likely to be as high as 11.8 mb/d by 1985 unless much more serious fuel production efforts are undertaken.

The International Economic Policy Association (Washington, D.C.) also issued a preliminary appraisal in June 1977, with special emphasis on the international economic implications of "America's Oil and Energy Goals." Pointing out that even if the Plan does achieve the goal (of 7 mb/d oil imports in 1985), the cost to the United States in that year would still be $37.1 billion (at a reference price of $14.52 per barrel, and in 1976 dollars). If imports do not drop to that level and reach 11.4 mb/d, the cost to the United States would rise to $60.9 billion for the year 1985 (also expressed in 1976 dollars and a $14.52 reference price).

ADMINISTRATION'S IEA STATEMENT

Energy Secretary James Schlesinger openly conceded shortfalls in the Plan in his statement to the governing board of the 19-member International Energy Agency (IEA) in Paris on Oct. 5, 1977:

"What we miss this year we are going back for next year. Indeed, we chose in January and the following months to gauge just about what we thought we could get through, recognizing that what we were proposing was a moderate program, [although] extraordinarily bold in relation to prior accomplishments in Washington, D.C. The goals were quite modest in terms of the gravity of the problem."

At the same meeting, the members of the IEA agreed to limit their combined oil imports to 26 mb/d by 1985. This will require all members other than the United States to hold imports at no more than current levels, and the United States to achieve a reduction in oil imports by 1985 to 5.8 mb/d, a renewed U.S. commitment which Secretary Schlesinger acknowledged other IEA members view with "understandable" skepticism.

REFERENCE SOURCES—ASSESSMENTS OF THE PRESIDENT'S PLAN

Congressional Budget Office, U.S. Congress. President Carter's energy proposal: a perspective. Staff Working paper, June 1977. 133 pp; executive summary presented in subsequent testimony: Statement of Alice M. Rivlin, Director Budget Office, before the Ways and Means Committee, House of Representatives, June 6, 1977

Congressional Research Service, Library of Congress. An initial analysis of the President's National Energy Plan. Prepared for the use of the Committee on Interior and Insular Affairs, House of Representatives, 95th Congress, 1st Session, June 1, 1977. 377 pp. plus appendices; updated for the Committee on Interstate and Foreign Commerce, House of Representatives, September 1977.

Congressional Research Service. Library of Congress, "The Carter coal conversion plan for industry: A critique", by David E. Gushee, Specialist, Environment and Natural Resources Policy Division, June 10, 1977, 5 pp. Prepared for Hearings held June 13, 1977 by the House Subcommittee on Oversight and Investigations, Committee on Interstate and Foreign Commerce.

General Accounting Office, preliminary letter report, addressed to The Honorable Jack Brooks, Chairman, House Committee on Government Operations from Elmer P. Staats, Comptroller General of the U.S., 15 pp. EMD–77–45. Final report, 182 pp. including appendices, July 25, 1977, EMD–77–48.

General Accounting Office, letter report relating to the National Energy Plan and national energy goals, addressed to the President of the Senate and the Speaker of the House of Representatives from Elmer B. Staats, Comptroller General of the U.S., 8 pp. including appendices, Oct. 14, 1977, EMD–78–5.

International Economic Policy Association. America's oil and energy goals: the international economic implications. A preliminary appraisal. June 1977. Washington. 45 p.

International Economic Policy Association. Perspectives on the National Energy Plan: A mid-course appraisal. September 1977. Washnigton. 27 p.

Office of Technology Assessment, U.S. Congress. Analysis of the proposed National Energy Plan. Prepublication draft. 281 p. and two appendices. June 24, 1977. Prepared in response to a request from the House Committee on Science and Technology and the House Committee on Interior and Insular Affairs. Final report, 243 p: August 1977.

The Business Round Table (An association of 180 major U.S. Corporations). Energy position paper. Sept. 12, 1977. New York. 12 p.

University of Texas at Austin. Preliminary assessment of the President's National Energy Plan. May 11, 1977, 412 p. Prepared by members of the faculty and staff at the University of Texas at Austin in response to a request from the Governor of the State of Texas.

SELECTED READINGS

A. ENERGY PROBLEM AND NATIONAL SECURITY

THE NATIONAL ENERGY PLAN: ADDRESS BY PRESIDENT CARTER

November 8, 1977

Good evening: More than 6 months ago, in April, I spoke to you about a need for a national policy to deal with our present and future energy problems, and the next day I sent my proposals to the Congress.

The Congress has recognized the urgency of this problem and has come to grips with some of the most complex and difficult decisions that a legislative body has ever been asked to make.

Working with Congress, we've now formed a new Department of Energy, headed by Secretary James Schlesinger. We have the ability to administer the new energy legislation, and congressional work on the national energy plan has now reached the final stage.

Last week the Senate sent its version of the legislation to the conference committees, where Members of the House and Senate will now resolve differences between the bills that they've passed. There, in the next few weeks, the strength and courage of our political system will be proven.

The choices facing the Members of Congress are not easy. For them to pass an effective and fair plan, they will need your support and your understanding—your support to resist pressures from a few for special favors at the expense of the rest of us, and your understanding that there can be no effective plan without some sacrifice from all of us.

Tonight, at this crucial time, I want to emphasize why it is so important that we have an energy plan and what we will risk, as a nation, if we are timid or reluctant to face this challenge. It's crucial that you understand how serious this challenge is.

With every passing month, our energy problems have grown worse. This summer we used more oil and gasoline than ever before in our history. More of our oil is coming from foreign countries. Just since April, our oil imports have cost us $23 billion—about $350 worth of foreign oil for the average American family.

A few weeks ago, in Detroit, an unemployed steelworker told me something that may reflect the feelings of many of you. "Mr. President," he said, "I don't feel much like talking about energy and foreign policy. I'm concerned about how I'm going to live. . . . I can't be too concerned about other things when I have a 10-year-old daughter to raise and I don't have a job and I'm 56 years old."

Well, I understand how he felt, but I must tell you the truth. And the truth is that you cannot talk about economic problems now or in the future without talking about energy.

Let me try to describe the size and the effect of the problem. Our farmers are the greatest agricultural exporters the world has ever known, but it now takes all the food and the fiber that we export in 2 years just to pay for 1 year of imported oil—about $45 billion.

This excessive importing of foreign oil is a tremendous and rapidly increasing drain on our national economy. It hurts every American family. It causes unemployment. Every $5 billion increase in oil imports costs us 200,000 American jobs, It costs us business investments. Vast amounts of American wealth no longer stay in the United States to build our factories and to give us a better life.

It makes it harder for us to balance our Federal budget and to finance needed programs for our people. It unbalances our Nation's trade with other countries. This year, primarily because of oil, our imports will be at least $25 billion more than all the American goods that we sell overseas.

It pushes up international energy prices because excessive importing of oil by the United States makes it easier for foreign producers to raise their prices. It feeds serious inflationary pressures in our own economy.

If this trend continues, the excessive reliance on foreign oil could make the very security of our Nation increasingly dependent on uncertain energy supplies. Our national security depends on more than just our Armed Forces; it also rests on the strength of our economy, on our national will, and on the ability of the United States to carry out our foreign policy as a free and independent nation. America overseas is only as strong as America at home.

The Secretary of Defense said recently, "The present deficiency of assured energy sources is the single surest threat . . . to our security and to that of our allies."

Yesterday, after careful consideration, I announced the postponement of a major overseas trip until after Christmas because of the paramount importance of developing an effective energy plan this year. I have no doubt that this is the right decision, because the other nations of the world—allies and adversaries alike—await our energy decisions with a great interest and concern.

As one of the world's largest producers of coal and oil and gas, why do we have this problem with energy, and why is it so difficult to solve?

One problem is that the price of all energy is going up, both because of its increasing scarcity and because the price of oil is not set in a free and competitive market. The world price is set by a foreign cartel—the governments of the so-called OPEC nations. That price is now almost five times as great as it was in 1973.

Our biggest problem, however, is that we simply use too much and waste too much energy. Our imports have more than tripled in the last 10 years. Although all countries could, of course, be more efficient, we are the worst offender. Since the great price rise in 1973, the Japanese have cut their oil imports, the Germans, the French, the British, the Italians have all cut their oil imports. Meanwhile, although we have large petroleum supplies of our own and most of them don't, we in the United States have increased our imports more than 40 percent.

This problem has come upon us suddenly. Ten years ago, when foreign oil was cheap, we imported just 2½ million barrels of oil a day, about 20 percent of what we used. By 1972, we were importing about 30 percent. This year, when foreign oil is very expensive, we are importing nearly 9 million barrels a day—almost one-half of all the oil we use. Unless we act quickly, imports will continue to go up, and all the problems that I've just described will grow even worse.

There are three things that we must do to avoid this danger: first, cut back on consumption; second, shift away from oil and gas to other sources of energy; and third, encourage production of energy here in the United States. These are the purposes of the new energy legislation.

In order to conserve energy, the Congress is now acting to make our automobiles, our homes, and appliances more efficient and to encourage industry to save both heat and electricity.

The congressional conference committees are now considering changes in how electric power rates are set in order to discourage waste, to reward those who use less energy, and to encourage a change in the use of electricity to hours of the day when demand is low.

Another very important question before Congress is how to let the market price for domestic oil go up to reflect the cost of replacing it while, at the same time, protecting the American consumers and our own economy.

We must face an unpleasant fact about energy prices. They are going up, whether we pass an energy program or not, as fuel becomes more scarce and more expensive to produce. The question is, who should benefit from those rising prices for oil already discovered? Our energy plan captures and returns them to the public, where they can stimulate the economy, save more energy, and create new jobs.

We will use research and development projects, tax incentives and penalties, and regulatory authority to hasten the shift from oil and gas to coal, to wind and solar power, to geothermal, methane, and other energy sources.

We've also proposed, and the Congress is reviewing, incentives to encourage production of oil and gas here in our own country. This is where another major controversy arises.

It's important that we promote new oil and gas discoveries and increased production by giving adequate prices to the producers.

We've recommended that the price, for instance, of new natural gas be raised each year to the average price of domestic oil that would produce the same amount of energy. With this new policy, the gross income of gas producers would average about $2 billion each year more than at the present price level. New oil prices would also rise in 3 years to the present world level and then be increased annually to keep up with inflation. This incentive for new oil production would be the highest in the whole world.

These proposals would provide adequate incentives for exploration and production of domestic oil and gas, but some of the oil companies want much more—tens of billions of dollars more. They want greatly increased prices for "old" oil and gas—energy supplies which have already been discovered and which are being produced now. They want immediate and permanent deregulation of gas prices, which would cost consumers $70 billion or more between now and 1985. They want even higher prices than those we've proposed for "new" gas and oil, and they want the higher prices sooner. They want lower taxes on their profits.

These are all controversial questions, and the congressional debates, as you can well imagine, are intense. The political pressures are great because the stakes are so high, billions and billions of dollars. We should reward individuals and companies who discover and produce new oil and gas, but we must not give them huge windfall profits on their existing wells at the expense of the American people.

Now the energy proposal that I made to Congress last April has three basic elements to ensure that it is well balanced. First, it's fair both to the American consumers and to the energy producers, and it will not disrupt our national economy. Second, as I've said before, it's designed to meet our important goals for energy conservation, to promote a shift to more plentiful and permanent energy supplies and encourage increased production of energy in the United States. And third, it protects our Federal budget from any unreasonable burden. These are the three standards by which the final legislation must be judged. I will sign the energy bills only if they meet these tests.

During the next few weeks, the Congress will make a judgment on these vital questions. I will be working closely with them. And you are also deeply involved in these decisions. This is not a contest of strength between the President and the Congress, nor between the House and the Senate. What is being measured is the strength and will of our Nation—whether we can acknowledge a threat and meet a serious challenge together.

I'm convinced that we can have enough energy to permit the continued growth of our economy, to expand production and jobs, and to protect the security of the United States—if we act wisely.

I believe that this country can meet any challenge, but this is an exceptionally difficult one because the threat is not easy to see and the solution is neither simple nor politically popular.

I said 6 months ago that no one would be completely satisfied with this National Energy Plan. Unfortunately, that prediction has turned out to be right. There is some part of this complex legislation to which every region and every interest group can object. But a common national sacrifice to meet this serious problem should be shared by everyone—some proof that the plan is fair. Many groups have risen to the challenge. But, unfortunately, there are still some who seek personal gain over the national interest.

It's also especially difficult to deal with long-range, future challenges. A President is elected for just 4 years, a Senator for 6, and our Representatives in Congress for only 2 years. It's always been easier to wait until the next year or the next term of office, to avoid political risk. But you did not choose your elected officials simply to fill an office. The Congress is facing very difficult decisions, courageously, and we've formed a good partnership. All of us in Government need your help.

This is an effort which requires vision and cooperation from all Americans. I hope that each of you will take steps to conserve our precious energy and also join with your elected officials at all levels of government to meet this test of our Nation's judgment and will.

These are serious problems, and this has been a serious talk. But our energy plan also reflects the optimism that I feel about our ability to deal with these problems. The story of the human race is one of adapting to changing circumstances. The history of our Nation is one of meeting challenges and overcoming them.

This major legislation is a necessary first step on a long and difficult road. This energy plan is a good insurance policy for the future, in which relatively small premiums that we pay today will protect us in the years ahead. But if we fail to act boldly today, then we will surely face a greater series of crises tomorrow—energy shortages, environmental damage, ever more massive Government bureaucracy and regulations, and ill-considered, last-minute crash programs.

I hope that, perhaps a hundred years from now, the change to inexhaustible energy sources will have been made, and our Nation's concern about energy will be over. But we can make that transition smoothly—for our country and for our children and for our grandchildren—only if we take careful steps now to prepare ourselves for the future.

During the next few weeks, attention will be focused on the Congress, but the proving of our courage and commitment will continue, in different forms and places, in the months and the years, even generations ahead.

It's fitting that I'm speaking to you on an election day, a day which reminds us that you, the people, are the rulers of this Nation, that your Government will be as courageous and effective and fair as you demand that it be.

This will not be the last time that I, as President, present difficult and controversial choices to you and ask for your help. I believe that the duties of this office permit me to do no less. But I'm confident that we can find the wisdom and the courage to make the right decisions—even when they are unpleasant—so that we might together, preserve the greatness of our Nation.

Thank you very much.

Note: The President spoke at 9 p.m. from the Oval Office at the White House. His remarks were broadcast live on radio and television.

STATEMENT BY THE HONORABLE HAROLD BROWN, SECRETARY OF DEFENSE

May 4, 1977

(Source: Hearings before the Ad Hoc Committee on Energy, U.S. House of Representatives, Ninety-Fifth Congress, First Session, on the National Energy Act)

Secretary Brown. Thank you, Mr. Chairman. I appreciate the committee's indulgence in scheduling, and I am very grateful for the opportunity to appear before your committee to discuss the energy question and its impact on national security.

Accompanying me is Assistant Secretary David McGiffert who is Secretary of Defense for International Security Affairs. Neither of us are experts on energy though I used to know something about it.

I do believe my present responsibilities as Secretary of Defense make me aware of the very substantial impact, in fact, the crucial nature, of the energy shortage and of the need for a U.S. program to redress it. In fact, there is no more serious threat to the long-term security of the United States and to its allies than that which stems from the growing deficiency of secure and assured energy resources.

A high rate of energy consumption is the hallmark of industrialized societies as we know them today. Even with severe and mandatory conservation to reduce consumption this will continue to be so in the future. The standard of living that now exists in the more developed nations, and to which the developing nations of the world aspire, is a very recent phenomenon. It first appeared in the United States about 50 years ago, and in the other parts of the world where it exists at all, only since the end of World War II. At present it rests on fossil fuels. More specifically, it is dependent on oil and natural gas, which account for 75 percent of U.S. energy consumption.

The enormous economic development which the world has seen in the 20th century, and particularly since World War II, including the phenomenal German and Japanese economic resurgence, has been almost entirely based on the fact that almost unrestricted and certainly inexpensive energy was available from oil and natural gas, with oil by far predominant. It follows therefore that a cutoff or deep reduction of oil and gas supply would result in the destruction or at least the crippling of the advanced free-market economies within a relatively short span of time. In 1973–74, the world had a very brief and very small sample of what an oil shortage can do. There is now, I believe, a general awareness of the fragile nature of the world's economic balance and its critical dependence on an unrestricted and expanding supply of oil. That awareness gives added credence to the potential for political, economic, or military pressure on us by those who have, or are perceived to have, the ability to halt or at least substantially reduce the global distribution of oil. Steps which reduce this dependence—by conservation, substitution of coal, or development of new, renewable sources—are therefore vital. We in the United States are fortunate that such measures can substantially reduce our dependence on outside sources, if we take the necessary steps, to the point where we can accumulate a stockpile equal to 6 months of imports. In the foreseeable future, our European and Japanese allies do not have such a prospect.

The threat to national security, the economy and our way of life which arises from the energy crisis is not yet fully recognized by all. Some refuse to accept the fact that the energy crisis is real, and that its solution will require development of a national policy and purpose commanding the dedication of the Nation, its resources, and its people over many years. Ultimately, the only alternative is disaster.

We are all familiar with the continuing risk of oil supply interruptions and upward pressures on prices from politically motivated embargoes such as we experienced 4 years ago. Much less attention has been given to the potential for a much more serious interruption of oil supply by hostile forces in time of war. In the event of some future confrontation, the Soviet Union might be able to restrict access of the Western World to its essential oil supplies to a degree of severity and duration greater than any embargo by the oil producers. The U.S.S.R. might attempt to deny access to the oil of the Persian Gulf by direct attack on the facilities of the major oil-loading ports, which lie near Soviet territory. Simultaneous action to interdict on the high seas tanker movement of oil from other exporting nations could vastly exacerbate the oil supply situation for the United States and its allies.

The military, political, and economic risks of oil interruption are very real, and are steadily increasing as dependence on imported oil continues to grow. We must do what we can to mitigate those risks during the years which must pass before the United States can again develop an acceptable degree of energy self-sufficiency. The potential adverse impacts on national security can and must be eased by adoption of the President's energy proposals, particularly those concerning the reduction of oil import dependence through energy conservation, the encouragement of domestic oil and gas production, substitution of coal and nuclear energy for oil and gas in electricity generation, and the development of a strategic petroleum reserve as insurance against periods of supply interruption.

There is a third and greater energy threat to the Nation which has until recently received all too little popular attention, but which, as the President has said, should be the foremost consideration in development of national energy policy. This third threat is neither military nor political. It is, quite simply, resource depletion. A finite world supply of oil and gas will soon repeat the cycle so long evident in the United States. Growth in producible reserves will slow, halt and then go into decline as the remaining proven undiscovered resources grow smaller and the rate of discovery diminishes in the face of steadily increasing demand. The annual expansion in worldwide production which has been the foundation of 20th century world economic growth will level off and begin to decline.

Arguments that much greater hydrocarbon reserves remain to be discovered miss the point. A growing consumption rate assures that even if so they too will be quickly consumed.

There is every indication that these turning points loom in the very near future. The time remaining to us to rectify the situation is very short. If the United States and the rest of the developed and developing world do not soon move strongly to reduce oil demand and increase supplies of energy from alternate sources, economic growth too will cease and the free world economy will go into long-term stagnation and decline. The consequences for free world security are all too apparent.

The 1973 oil embargo and the world recession which it helped induce, arrested and indeed rolled back the growth in oil consumption for a brief 2 years. The free world was thus given more time to get its energy house in order—not by its own endeavors, but by the actions of the oil-exporting nations. The pause was short. Driven by a 6.9-percent increase in U.S. oil consumption, world crude oil production again rose sharply in 1976 to an all-time high of 57 million barrels per day. U.S. domestic demand, at 17.4 million barrels per day, almost equalled the consumption rate prevailing just before the embargo. Renewed economic growth here and abroad raises the probability that demand growth will again rise exponentially at near pre-embargo levels unless conservation efforts are maximized and shifts of energy demand to alternate fuels can be effected in accordance with the President's program.

Inevitably, United States and allied needs for hydrocarbon imports constrain our foreign policy and create potential risks of confrontation and military conflict. DOD interest focuses primarily on maintaining the U.S. defense posture by avoiding disruptions or the threat of disruptions of energy supplies to the armed services and the industrial mobilization base. In the broader context of U.S. national security, DOD also wishes to avoid any policy which would adversely impact on U.S. allies and thereby indirectly weaken the United States. Furthermore, the Department of Defense is crucially aware of the prospect for the depletion of world liquid petroleum reserves and the need to begin now to conserve energy resources.

We in Defense believe that:

The United States needs to minimize its dependence on Persian Gulf oil and develop alternative sources of supply preferably in the Western Hemisphere.

The United States should secure a billion barrel petroleum stockpile as quickly as possible.

The United States should develop alternative supplies of energy, both conventional and nonconventional, to reduce demand on a depleting world oil resource base.

I believe there is comparatively little time for the United States to respond to the President's call and move toward reducing its dependence on imported oil. Failure to do so will impose increasing risks to our national security in the next few years and lead inexorably to the collapse of the world oil supply/demand balance in the next decade. Should that occur the effects on the security and economic viability of this Nation and the free world will be catastrophic.

Thank you, Mr. Chairman.

A STATEMENT BY THE CHAIRMAN OF THE HOUSE AD HOC COMMITTEE ON ENERGY

(By Hon. Thomas L. Ashley of Ohio, in the House of Representatives, Wednesday, October 12, 1977)

[From the Congressional Record, Extensions of Remarks, Oct. 12, 1977]

Mr. Ashley. Mr. Speaker, a little more than 2 months ago this body passed and sent to the Senate H.R. 8444, the National Energy Act. According to your instructions, the five standing committees worked long and hard to meet exacting deadlines and deal with a massive bill that will result in a number of hard choices for the United States. The Ad Hoc Committee on Energy which I had the honor to chair considered the program as a whole, recommended certain amendments to the House of Representatives, and we hammered out a tough—but, we thought, fair—energy program for the crucial period between now and 1985.

It is no secret, Mr. Speaker, that the President's energy program as passed by the House has been severely curtailed in the Senate. I do not intend to discuss this at this point; we will be going to conference with the Senate in the near future, and we have high hopes of being able to produce a creditable energy bill.

To borrow a phrase from another generation, Mr. Speaker, the whole world is watching what we do here. If we cannot bring ourselves to send a strong signal to the world that the United States is taking seriously the ominous prospects of the energy situation, it is hard to see how smaller, less prosperous countries can be persuaded to take the steps necessary to buy the time needed to develop new sources of .energy.

Last week, the International Energy Agency, a consortium of 19 countries, including the United States, who depend on oil for the continued health of their economies, met in Paris at the ministerial level. They made a joint decision to reduce their combined oil imports to 26 million barrels a day by 1985. This is an ambitious goal. It will take extraordinary measures to meet it, in our country as well as in the other nations. Yet meet it we must, because as Secretary Schlesinger said in his remarks to the assembled energy Ministers, there is a very good chance that there will be only those 26 million barrels a day available to all the importing nations.

The United States accounts for a major portion of those oil imports. Their cost is seriously affecting our balance of trade. We are on a collision course with economic disaster, unless we take some steps that may be painful for our special interests, but which are vitally needed for our long-term national interest.

As Secretary Schlesinger said to the IEA Ministers:

"The principal problem is one of sense of purpose, and the development of political will in each of our countries to achieve conservation, shift to more abundant sources of supply, and rapidly develop alternative sources of energy."

Mr. Speaker, I urge my colleagues in both bodies of this Congress to preserve and strengthen that sense of purpose we all shared when the President set his goals for a national energy policy.

I believe that the resolutions taken at the International Agency meeting and the words spoken by our Secretary of Energy there will help to restore our perspective to this critical energy problem. I would like to share them with my colleagues:

DECISION ON GROUP OBJECTIVES AND PRINCIPLES FOR ENERGY POLICY ADOPTED BY THE GOVERNING BOARD OF THE IEA MEETING AT MINISTERIAL LEVEL ON OCTOBER 5, 1977

The governing board considering:

That the world is confronted with the serious risk that as early as the 1980's it will not have sufficient oil and other forms of energy available at reasonable prices unless present energy policies are strengthened:

That such a situation would have severe economic, social and political repercussions in all International Energy Agency countries and throughout the world;

That IEA countries must help reduce this risk by a strong and sustained policy response designed to make more effective use of energy resources and put more emphasis on less depletable energy sources;

That prompt action in this regard should be a major and essential element of IEA countries' energy policies in the development of their general economic strategy, taking into account environmental and safety aspects of the use of energy resources;

That the policy response of IEA countries should be concerted, having regard to the consequences of action in individual IEA countries for energy supply and demand in other countries, and taking into account the provisions of the Agreement on an International Energy Program and the Long-Term Co-operation Programme:

Decides:

1. That, in order to maintain equilibrium in energy market conditions, it will be the objective of IEA countries as a group to hold their total oil imports to not more than 26 million barrels per day in 1985; and that they will establish group objectives for successive periods;

2. That, in order to achieve the group objectives, IEA countries will reinforce their present efforts:

(a) By endorsing the Principles for Energy Policy set forth in Annex I hereto, which IEA countries are determined to follow in the establishment and implementation of national energy policies;

(b) By contributing, as individual IEA countries, to the achievement of the group objectives through the energy policies and measures which they adopt; the individual statements set forth in Annex II hereto describe the policies and measures which Governments intend to take for this purpose, having taken into account the Principles for Energy Policy set forth in Annex I hereto and the results of the IEA's country reviews;

(c) By reviewing systematically each year within the review process of the International Energy Agency:

The contribution of IEA countries to the achievement of the group objectives referred to in paragraph 1;

The continuing validity of the group objectives; and

The need for establishment of objectives for later years;

taking account of IEA countries' individual circumstances (including the timing considered appropriate for the implementation of energy policies), of the Principles for Energy Policy set forth in Annex I hereto, of the policies and measures stated in Annex II hereto, and of the need for ensuring equivalence of effort among all IEA countries;

(d) By accepting the need to further strengthen—by national action supplemented where appropriate by concrete measures for international cooperation and solidarity with due regard for the financial and technological implications—their policies and measures as may be necessary to meet the group objectives, taking into account the results of the reviews in the International Energy Agency.

ANNEX I

Principles for energy policy

1. Further development by each Participating Country of national energy programmes and/or policies which include the objective, formulated as specifically as possible, of reducing in absolute terms or limiting future oil imports through

conservation of energy, expansion of indigenous energy sources and oil substitution.

2. Constant and careful attention to important environmental, safety, regional and security concerns to which the production, transportation and use of energy give rise, and improvement of the speed and consistency of public procedures for resolving conflicts which may exist between these concerns and energy requirement.

3. Allowing domestic energy prices to reach a level which encourages energy conservation and development of alternative sources of energy.

4. Strong reinforcement of energy conservation, on a high priority basis with increased resources, for the purpose of limiting growth in energy demand relative to economic growth, eliminating inefficient energy use, especially of rapidly depleting fuels, and encouraging substitution for fuels in shortest supply, by implementing vigorous conservation measures in various sectors along lines which include the following elements:

Pricing policies (including fiscal measures) which give incentives to conservation;

Minimum energy efficiency standards;

Encouragement and increase of investment in energy saving equipment and techniques.

5. Progressive replacement of oil in electricity generation, district heating, industries and other sectors by:

Discouraging the construction of new exclusively oil-fired power stations;

Encouraging the conversion of existing oil-fired capacity to more plentiful fuels in electricity, industrial and other sectors;

Encouraging the necessary structural adjustments in the refinery sector in order to avoid an excess of heavy fuel oil;

Directing efforts to the reduction of the use of heavy fuel oil as a primary energy source in those sectors where efficiency is low.

6. Application of a strong steam coal utilisation strategy and active promotion of an expanded and reliable international trade in steam coal, composed of the following elements:

Rapid phasing-in of steam coal as a major fuel for electrical power generation and in industrial sectors;

Further development of steam coal policies within producing, exporting and consuming IEA countries to support increased utilisation by enhancing market stability through reliable and increased export and import flows under reasonable commercial terms;

Development of policies to remedy anticipated infrastructure bottlenecks.

7. Concentration of the use of natural gas on premium users' requirements, and development of the infrastructure necessary to expand the availability of natural gas.

8. Steady expansion of nuclear generating capacity as a main and indispensable element in attaining the group objectives, consistent with safety, environmental and security standards satisfactory to the countries concerned and with the need to prevent the proliferation of nuclear weapons. In order to provide for this expansion, it will be necessary through cooperation to assure reliable availability of:

Adequate supplies of nuclear fuel (uranium and enrichment capacity) at equitable prices;

Adequate facilities and techniques for development of nuclear electricity generation, for dealing with spent fuel, for waste management, and for overall handling of the back end of the nuclear fuel cycle. (The following Delegations expressed individual positions regarding Principle No. 8, as set forth in the Conclusions of the Meeting of the Governing Board which adopted this Decision: Denmark, The Netherlands, New Zealand, Norway, Spain, and Sweden.)

9. Stronger emphasis on energy research, development and demonstration, including collaborative programmes, more intensive national efforts and greater co-ordination of national efforts, in order to make energy use more efficient and to meet future energy requirements. Each Participating Country should contribute to energy technology development, with emphasis on (a) technologies which can have relatively near-term impact, (b) policies which facilitate the transition of new energy technologies from the research and development phase to the point of utilisation, (c) technologies for broadly applicable renewable energy sources, and (d) investigation of whether there are technological possibilities for significant contributions from other renewable resources, through:

Providing the fullest possible financial support for energy research, development and demonstration;

Increasing participation in international collaborative projects to extend the effectiveness of funds available;

Encouraging investment in energy technology development by appropriate incentives;

Ensuring that R & D policies remain consistent with and supportive of the objective of ongoing energy policy.

10. Establishment of a favorable investment climate which encourages the flow of public and private capital to develop energy resources by appropriate pricing policies, by minimising uncertainties about the general directions of energy and other policies such as mentioned in Principle 2, and by providing government incentives where necessary, in order to:

Give priority to exploration activities including those in offshore and frontier areas;

Encourage rates of exploration and development of available capacities which are consistent with the optimum economic development of resources.

11. Providing in energy policy planning for alternative means, other than increased oil consumption, for meeting any development of supply shortfall or failure to attain conservation objectives, taking into account the appropriate requirements of economic development and social progress.

12. Appropriate co-operation in the field of energy, including evaluation of the world energy situation, energy research and development and technical and financial requirements, with developed or developing countries or international organisations.

JAMES SCHLESINGER, U.S. SECRETARY OF ENERGY, STATEMENT TO THE MEETING OF THE GOVERNING BOARD OF THE INTERNATIONAL ENERGY AGENCY AT THE MINISTERIAL LEVEL, OCTOBER 5, 1977.

Thank you, Mr. President.

Mr. President, you have stressed the gravity of the situation we prospectively face and I would like to underscore that point. Because each projection of supply/demand balance that we develop this year tends to be less favorable than the one we developed in the prior year. So that the point at which prospective demand for petroleum internationally exceeds that of prospective supply comes nearer and nearer. It now appears likely to manifest itself in the early 1980's. And therefore the question that was raised earlier with regard to access to supply is not only a matter of effective and favorable American policy. It is something that we are going to have to face ultimately. We may not be in a position in the middle 1980's, irrespective of other policies to guarantee access to supply at whatever price. The Secretary General, Mr. Van Lennep has urged us to formulate policies here today, and indeed we should. But we should also recognize that we already know what the policies must be. We already know what steps it is necessary for us to take. So it is less a question of the formulation of policies than a common determination, and a determination in each of the nations here represented to see that those policies are effectively implemented, painful as it may be internally.

And given the nature of our body politics, which are democracies, it becomes quite difficult to achieve the results of making sacrifices now against a goal which is in the somewhat more distant future. We already know what the substance of our policies must be, conservation, shifting to more abundant sources of supply, the more rapid development of alternative sources of energy. The problem of substance is not the principal problem that we face. The principal problem is one of sense of purpose, and the development of the political will in each of our countries to achieve that end. I speak for but one country. But I think that I have detected so far in the discussion some of the curiosity regarding the political will in the United States on this matter. It is, I gather, from your perspective like going to bed with a elephant. There is an apprehension the elephant might turn over and there is very little that one can do about it. And I can well understand some of the skepticism in the wake of the President's program. You have heard some of it before, starting with Project Independence in 1974. Project Independence was to reduce our oil import demand to zero. And it has not to this date been successful. President Ford's program was designed to reduce our external oil demand to 3 to 5 million barrels a day. We have not yet gotten there. So skepticism may be understandable on your parts. I think that there is a difference here, a number of differences that I will stress in regard to the President's program.

First, there is, I think, a clear-sighted recognition of the problem, and that it is not a problem that will be dissipated by rhetoric, by a wave of the wand. I think. secondly, that we recognize the very great difficulties in getting oil demand down to the level where we are a zero importer as we envisaged in Project Independence.

And a much clearer recognition associated with that, that however great our own resources in the area of oil, they are limited. And, finally, we have established an objective which is hard. Let me stress that. It is hard given the character and the historical experience of the American people, who have been used to boundless expansionism and do not recognize readily finite limits. It will be hard to get down to the 5.8 million barrels a day import that the President's plan projects. But it is necessary. And let me stress that in a democracy the President has done something rare and unique: to ask for present day sacrifices to deal with the problem that goes well beyond the next election.

The problems with democracies are that they are inclined to get by with too little or too late and to put off the day of reckoning. The President has been prepared to pay the political costs. And I think that we will have success. I will come back to that in a moment.

You are all familiar with the program, which has been widely welcomed, far more widely and enthusiastically welcomed outside the United States than inside the United States. But it is designed from this standpoint to do three things: to reduce the rate of energy growth below two per cent a year; to curtail oil imports from a prospective 16 million barrels a day, were that oil available in 1985, to less than six million barrels a day and to reduce gasoline consumption by ten per cent. That means taking on the American motorist and that is a formidable force by itself. The only more formidable force that I know is the French motorist.

The important thing that I should state is that the goals have been generally accepted by the Congress and by the American people. There is an intellectual appreciation that indeed we have an energy problem. There was not that appreciation prior to January 20, or prior to the President's speech on April 18. Of course an intellectual appreciation is not sufficient. While many people recognize that somehow or other there is a problem, down in their visceras they have not necessarily developed the fortitude to deal with it. But we shall deal with that presently. And we recognize that we have a unique responsibility. We have a unique responsibility for a number of reasons that I shall not bore you with. First, because of our size, secondly because of our national resources, resources that exceed that of other members of this group save those that border on the North Sea.

We cannot do it alone, as you know. It is necessary for us to have a high degree of cooperation from other states. We thoroughly endorse the goal of reduced dependence. That goal of reduced dependence—26 million barrels a day—will be dependent critically upon the success of the American experiment. Unless we are able to force consumption down to a level that requires less than six million barrels a day, quite obviously the 26 million barrels a day goal will not be achieved as a matter of policy. It will however, in all likelihood be achieved as a matter of brute force, because it does not appear now that there is going to be much supply in excess of 26 million barrels a day available to the IEA countries in 1985. If reality is forcing this policy upon us, let us accept it and consciously take those measures to deal with it, rather than to allow reality to creep up on us over the years and then suddenly overpower us with drastic implications for employment, inflation and for virtually insolvable balance of payments difficulties. There is one final point that I wanted to make prior to a brief discussion of where the energy program stands. And that is the necessity of nuclear power. That is enshrined in the President's program. There have been differences of view with regard to such matters as the timing of deprocessing, the character of reprocessing, the urgency of breeder development. But it should be clearly understood that in the American program nuclear power is regarded as indispensable. I think that in dealing with your own publics that this should be stressed, rather than what has occasionally been suggested that somehow or other the Administration in Washington is antinuclear. The program stresses total endorsement of the present generation of technology. The program also stresses, and I recognize there are differences of opinion in this regard, a certain caution and wariness before moving into the next generation of technology. But there is no question about the need to employ nuclear power more than we have in the past. I go back to the remarks of the President with regard to the gravity of the problem, the fact that our forecasts each year are more depressing than the previous year's forecasts and the very lively probability that whether or not we endorse a goal of 26 million barrels a day in 1985, something like 26 million barrels a day will be all that we will have to play with. So the policy will be continued emphasis on nuclear power.

And, of course, we intend to make much more use of our coal reserves. All of this reflects a slow and dawning recognition of the gravity of the problem that the United States faces.

Mr. Brunner, you have told us to send them a message. We shall certainly take advantage of that opportunity. But the message, at least in part, has been received. As you know, despite great skepticism, the House of Representatives acted on the President's program very quickly and very solidly. There were some elements that we removed. But within a matter of 90 days, a radical change in American policy was endorsed by the House of Representatives. Unfortunately at that time the Congress went into recess. And when the Senators went back to their States they encountered the representatives of the affected parties, as a result they came back into Washington somewhat more doubtful than exuberant.

Nonetheless, there is a momentum about this program such that it will be accepted in large part by the United States Senate. One can be deceived by reading the press today. Because in the press one sees stunning defeats in the headlines followed by stunning victories, up and down. There is much less action out there than one would infer from reading those headlines. We will expect to be reasonably successful in the program and we expect to have the legislation in place shortly. What we miss this year, we are going back for next year. Indeed, we chose in January and the following months to gauge just about what we thought we could get through, recognizing that what we were proposing was a moderate program, extraordinarily bold in relation to prior accomplishments in Washington, D.C. The goals were quite modest in terms of the gravity of the problem.

In subsequent years we will have to go back for additional legislation irrespective of whether we get the entire package. I do not expect to get the entire package, but I know that each year we will learn new things about technology, uncertainties will be resolved, there will be new opportunities to pursue. And as a consequence we will have to alter the composition of the energy package. But the President is fully determined to pursue this matter. We have the tools that are necessary for getting much of the work done and we will obtain the additional tools as they are required.

Let me reiterate. There is no question about the goals. The goals have been endorsed by the United States Congress. That means we are establishing a monitoring device so that any shortfall provides us with the justification to go back for additional legislation.

I have no doubt that in this matter we will gradually wear away the resistance. Indeed the resistance has been far less than we anticipated some months ago. Therefore I offer you these small hopes to dispel whatever skepticism you may have brought to this room, hoping that whatever skepticism that you carry away from this room will be much less than what you brought into it.

We are not doing this as a matter of virtue, but as a matter of necessity. We recognize that the United States probably is better able to compete for certain energy sources than other nations. That imposes upon us a greater responsibility.

We have the responsibility, it seems to me, to continue to play a leadership role in this matter as in other matters and to the best of the ability of this Administration, we shall exercise it. That is part of our motivation. But the other part of the motivation is that we just have no choice. In the aggregate, the oil will not be available much beyond 1983 or 1985 or 1987 and we are all going to have to make this transition. We have about seven or eight years in which to make adjustments with some pain, but relatively painlessly. And that means that we begin now to take advantage of the time while we still have time to alter the capital stock of the United States in our case, to alter the capital stock of other countries, which is their responsibility so that we all become less oil dependent. Unless we do that, we will go on, slowly creating a capital stock that depends upon a continual rise in the flow of oil which will not be there, leading to gross wastage in future years and, of course, rising unemployment and a higher rate of inflation. These are fundamental problems. Democracy is a splendid form of government to live under, frustrating at times, but, as Winston Churchill said, its advantages are not so clear until one looks at the alternatives. But democracy is a fragile form of government. And we are facing collectively and individually one of the most dramatic transitions through which the world and the economic world must go—transition away from cheap and abundant oil. Unless we take advantage of the time that we have and unless we wish to avoid going steaming into that wall in the middle 1980's, we will unleash, I fear, a degree of political and social unrest of a sort that we in the United States have not witnessed in the 1930's. I cannot refer to the experience of other countries; on the solution of this problem, rests the future of our free societies.

That is the fundamental basis on which the President has chosen to take action. It is a reflection of his commitment and his determination. We intend to carry it through. We cannot afford to fail. Thank you very much, Mr. President.

ENERGY IN THE COMING DECADE

(Speech by Under Secretary for Economic Affairs of the Department of State, Richard N. Cooper, Before the Annual Business Forecasting Conference at the University of California, Dec. 8, 1977)

Four years ago, the energy crisis was visible at every gas station. Last winter the energy crisis was felt in cold homes and closed factories. But in between emergencies, the energy crisis becomes a matter of statistics and political argument, rather than palpable distress. I am concerned that we as a nation are not aware of the full peril we face. As imported oil approaches 50 percent of our domestic consumption, for example, only about half of the American people even realize that we must import oil. And a recent poll indicated that only 12 percent of the public thinks there could be a shortage of oil within the next 15 years.

This lack of awareness is in some ways understandable. Not only are there no lines at the gasoline stations today, but there is more worldwide capacity to produce oil at present than there is demand at prices set by the 14-nation Organization of Petroleum Exporting Countries (known as OPEC). With new sources of production from Alaska and the North Sea, we may have a few years of soft oil market. But as we enter the 1980's, there is every reason to believe that the market will get tighter, unless we take tough action now to curb demand and increase domestic supply.

In 1985, according to recent studies, the total demand for OPEC oil by the non-Communist countries, assuming present energy policies continue, could range between 44 and 49 million barrels per day. Though OPEC productive capacity might amount to as much as 40-45 million barrels per day, its likely level of production, due to economic and political considerations, might be more on the order of 36 million barrels per day, up from 31 million barrels per day in 1977. We therefore have a potential daily shortfall of up to 13 million barrels. This prospective shortfall translates into the threat of another leap in prices, with all that went with the last one—inflation, recession, and prolonged economic disruption.

I hardly need remind you how different the impact of an increase in the price of oil is from that of other commodities. A drastic rise in the price of strawberries may cause anguish among strawberry lovers and may compel some minor adjustments among the consumption habits of the public at large; but the economy as a whole would not be affected. Oil is different. A price rise here is pervasive in its inflationary impact, both directly and indirectly through the prices of many other products. Perhaps paradoxically, it also has a powerful deflationary, or perhaps one should say contractionary, effect on aggregate economic activity. And the process of adjusting our economy and society to sharply higher energy costs is particularly long and difficult.

Our physical capital stock has been built up over the past 30 years on the assumption of cheap and plentiful oil and gas. We can see this in the style and location of our homes and buildings, the structure of our cities, our transportation systems, and the choice of productive techniques in our factories and on our farms. Because the assumption of cheap energy is so deeply rooted in the current structure of our economy, adjustment to a period of shortage is exceedingly difficult. (By "shortage" I use the economist's conception, which will not typically involve physical shortages if prices are free to move; rather, the hardship takes the form of sharply higher energy bills and painful, induced retrenchment of demand.) To avoid sharply higher prices, forced-pace adjustment, and severe social and economic dislocations, we must anticipate the coming crisis before we get all of the market signals.

The pain of adjustment can be greatly reduced if it can be spread over a period of time and adapted to the natural capacity of our economy to adjust. We need to make sacrifices now—to alter lifestyles and business practices—to enable us to meet and overcome a crisis looming in the somewhat distant future. Anticipating future calamities is perhaps the most difficult challenge for a democracy. But it is a challenge that we, as well as our allies, must meet if our economic and political systems are to remain healthy and vigorous in the 1980's.

The domestic and international aspects of the energy problem are intertwined. Whatever our problems, the situation of other industrialized democracies is more precarious. Most are far more dependent on imported oil, and since most now use energy more sparingly than do we, they have far less fat to shed before their economies become hostage to a shortage of oil. They are limited, however, in what they can do on their own to improve their situation, and their financial circumstances are typically weaker than ours.

I have emphasized thus far the problems arising from a likely shortage of oil in the mid-1980's. I do not need to remind you that we may not have to wait until then to experience these problems. We are presently vulnerable to disruption in the supply of oil from any source, whether it be from a politically motivated embargo or even a significant terrorist disturbance. Our vulnerability was dramatically demonstrated in late 1973; it is far greater now. Even the mere possibility of a supply disruption has a significant effect not only on economic decisions, but also on national security considerations. A concentrated dependence on foreign sources for any vital material reduces our freedom of action and leaves us open to threats. The potential effects are, of course, even greater on our allies, with their greater dependence on imported oil. Their sense of vulnerability to disruption of oil supplies increases considerably the burden upon us.

With only 6 percent of the world's population, we consume one-third of the world's energy production, at a rate of the equivalent of a barrel of oil per week per person. We use twice as much energy per person as Germany or Sweden, nations with roughly our standard of living. Although our own production is still substantial, we now in addition absorb nearly one-third of total OPEC oil production.

The United States is the world's largest energy consumer and the largest oil importer. If we do little to reduce our dependence on imported oil, the most ambitious efforts of the other industrialized nations to prevent a future shortfall will be futile. Despite this fundamental truth, our efforts to reduce our dependence will not prevent a shortage if others continue to significantly expand their oil consumption.

If our nations do not prepare for the oil shortfall in the 1980's, the framework of international cooperation which we have worked so hard to build since World War II will be imperiled. Severe economic disturbances would be followed in some countries by political instability. The trend toward freer international trade, which has been responsible for much of our post World War II prosperity, would surely be reversed under conditions of recession and oil-induced balance-of-payments difficulties. The prosperity and cohesion of the Western industrialized nations would be at stake, putting in jeopardy our own security and ultimately our way of life.

The non-oil-producing developing countries would also be hard hit economically. These nations are not profligate energy users; these use very little energy, but their economic development—both in industry and in agriculture—depends on the availability of imported energy. If oil prices are rising, the burden on the already fragile external financial condition of these countries could become insupportable. The cost of their imports would rise, and in world recession their exports would contract. Economic development would stop, if not regress.

To prepare for the energy crisis as it affects us now, and will affect us even more seriouly in the future, President Carter determined that one of the first priorities of this Administration would be to develop a comprehensive energy program that will cut the growth of our energy consumption and reduce the demand for imported oil. The President's program aims at lowering the annual growth of energy consumption in the United States to less than 2 percent by 1985, compared to an average 3.5 percent from 1950–73. And it would reduce our oil imports in 1985 from a possible 12 million barrels per day to 6 million.

This program would have the not merely incidental benefit of helping to reduce our huge trade deficit, which with oil imports now costing $45 billion a year is more than fully accounted for by our recent recent heavy dependence on imported oil.

Our energy program is only part of a broader effort to insure that the energy crisis does not suddenly overwhelm the entire international system.

We intend to continue our nation's leading role in the work of the International Energy Agency, an organization that includes Canada, Japan, and most of the industrialized democracies of Western Europe, as well as the United States. The IEA has already done much to transform the energy problem from a potentially divisive force into a unifying one. It has developed an emergency plan which would insure that the burden of supply disruptions would be borne equitably, thus avoiding a repetition of the uncoordinated and collectively harmful reaction to the 1973 oil embargo.

The IEA is also vitally concerned with reducing its members' dependence on imported oil. Ministers of the IEA nations, including (Energy) Secretary Schlesinger, agreed recently in Paris to hold their total oil import demand to not more than 26 million barrels a day by 1985; down from a probable figure of 36 million barrels, if current policies continue. Obviously this goal has to be backed up by strong domestic action by each of the member nations, or it will simply float off to join so many other well-intentioned, but ineffectual, objectives uttered at international forums. We and other members intend to examine closely the energy policies of all IEA nations and to treat seriously any lack of progress toward reaching our collective goal. But the United States is the key country; unlike any other nation, if we alone fail to do our share, the goal will never be reached.

We are urging the non-oil-producing developing countries to make maximum use of private sector resources to expand their production of energy. To help meet the financial requirements of such an effort, we are supporting an increase in World Bank lending for energy development.

And in the coordination of international economic policy with our major allies, we are trying to insure that the efforts of individual countries to cope with the burden of oil debt do not result in trade protectionism or exchange restrictions that could ultimately undermine the liberal international economic system.

Consuming nations are, of course, only one side of the energy equation. Actions of the oil-producing nations, particularly the members of OPEC, are critical to the world economy and to the future of the world's energy supply. In our view, international energy policy must be a cooperative endeavor. The oil-consuming nations, particularly the United States, have a responsibility to the rest of the world (as well as to themselves) to control their consumption and to develop alternative sources of energy. The oil-producing nations, in turn, must take into account the effect of their price and supply actions on the world economy. It is in their own interest, as well as that of the developing and developed worlds, to avoid further disruption in world trade and prosperity.

Thus there is a kind of inescapable bargain which must be made between oil-producing and oil-consuming nations. It is an arrangement based on deeds, not words or agreements, and it is dictated both by the self-interest of each side and by the economic facts of life. The terms are simple: Consumers must restrain demand; producers must restrain prices and expand production to meet that demand.

The basis for this relationship can be clearly seen by considering the alternative. If consumers do not restrain demand, production will be inadequate, and prices may take another dramatic leap. If producers raise prices continually and without economic justification, the world economy will suffer cumulatively increasing damage, and the financial and political stability will be undermined.

I would now like to return briefly to the President's energy plan. As you know, it operates both on the supply and demand for oil and the supply and demand for energy. The two do not always correspond. An increase in the demand for energy need not be accompanied by an increase in the demand for oil. In fact, the plan provides for modest growth in energy use while it would hold oil consumption to just slightly above the 1976 level.

With respect to demand for energy, the potential for additional conservation is clear. As noted above, we use twice as much energy per person as Germany or Sweden, nations with roughly our standard of living. Some of that energy use is careless waste, reflecting a bygone era of cheap energy. Much is built into existing structures and location patterns. Reducing energy demand in these sectors often is not free. It requires investment and should be judged by a test of cost-effectiveness. Measured by that test, there is enormous potential for profitable investment in conservation—home insulation, new energy control techniques in existing plants, new plants and equipment which are optimized according to current and future energy prices. Conservation is not simply a slogan or an exhortation to good citizenship. It is a field of opportunity for investment and innovation by American business and homeowners.

Many of the programs you have adopted in California—utility rate reform, incentives for utilities to undertake vigorous conservation programs and for customers to purchase solar equipment—have helped shape the national energy plan and can be a model for other states.

Supply is an equally important feature of the President's energy strategy. The plan calls for an increase by two-thirds in the production of coal, to more than a billion tons per year by 1985. It provides steps to stimulate substitution of coal for oil and natural gas, as well as to overcome some of the present economic, social, and environmental constraints upon its use.

The production of nuclear energy is projected to increase significantly. The plan is directed toward use of the light water reactor and defers the early commercialization of technologies which have not been fully developed or safeguarded against potential misuse, particularly the breeder reactor. Expansion of the production of nuclear energy is an essential part of the effort of the United States and other industrialized nations to reduce our collective dependence upon imported oil. We believe it can be done in a manner which will not threaten our safety or our environment.

The plan also provides incentives for the development of new sources of domestic oil and natural gas. Contrary to widespread misinterpretation, the price incentives (after allowance for taxes) are generous by any reasonable standard—more generous, in fact, than incentives to produce new oil and gas almost anywhere else in the world.

We cannot afford, however, to lull ourselves into the expectation that domestic drilling will tap vast new reserves of oil or gas. Our nation has probably been explored as thoroughly as any other. We can expect to increase production somewhat over the next 10 years; but for the supply of domestically produced energy to fuel an expanding economy, we will have to look to coal, nuclear, and other sources.

We must also keep in mind that oil and natural gas may ultimately be most valuable to us as raw materials. They are used as feedstocks for petrochemicals, fibers, plastics, and pharmaceuticals, as well as in lubricants, waxes, and asphalt. While we have now, and expect to develop, alternatives for many of the uses of oil and gas as fuels, it may be more difficult or more costly to find adequate substitutes for these other uses.

A long-run solution to the energy problem involves more than oil and gas. The world economy must shift over time to non-fossil fuels, particularly to renewable resources. Sources which once seemed exotic, and which are now small-scale or experimental, will one day be routine. Solar energy, for example, offers enormous potential for the future—and specific, cost-effective applications for today. Solar water heating is already competitive with gas or electricity in parts of the country. Costs of photovoltaic cells are declining substantially, and this form of solar electricity may soon be practical for numerous remote areas. Wind and geothermal energy could make a useful contribution by the year 2000. And the U.S. Government is actively pursuing, along with other nations, advanced forms of nuclear fusion and fission which would meet our concerns about the nonproliferation of nuclear weapons.

For as far as we can see into the future, we shall have to make difficult decisions about energy. There is no "quick fix," no single policy cure-all. Instead there are a series of practical measures that we can take now in order to preserve our chances for prosperity and security for the years to come. It is a privileged position for any generation to be able to foresee and adapt to the problems of the future. We should not miss that opportunity.

B. FEDERAL PROCUREMENT OPTIONS

TESTIMONY OF THE HONORABLE HAROLD BROWN, SECRETARY OF DEFENSE, BEFORE THE HOUSE AD HOC COMMITTEE ON ENERGY, MAY 4, 1977

(Excerpts)

Department of Defense Procurement of Petroleum From Foreign Sources

Department of Defense worldwide petroleum consumption during fiscal year 1976 was approximately 173 million barrels. The Air Force was the predominant user, accounting for 57 percent, while Navy and Army consumption was 30 and 10 percent, respectively. Combined Marine Corps and DOD Agency energy use accounted for the remaining 3 percent.

Petroleum products procured from overseas sources in fiscal year 1976 represented 22.3 percent of the total quantity procured by the Defense Fuel Supply Center or approximately 38.6 million barrels. The following table identifies overseas procurement by product category as a percent of all overseas procurement and as a percent of total DOD procurement of that product category:

	Percent of all overseas procurement	Percent of total product procurement
Avgas	0.4	7.3
Jet fuel	47.0	15.9
Distillates	41.4	40.6
Residuals	4.8	14.9
Mogas	6.4	46.4
Total	100	

Mr. Rogers. Now, do we have sufficient oil to replace that in case that is taken away?

Secretary Brown. Well, if the sources overseas dry up in the Mediterranean, for example, that would be in connection with some other problem which I think might have more direct effect; in other words, if a war starts there.

Mr. Rogers. Well, it may happen without a war.

Secretary Brown. That could happen without a war.

Mr. Rogers. An embargo?

Secretary Brown. That is right. We went through that once.

Mr. Rogers. I understand.

Do we have sufficient capability to replace it, that is what I am asking?

Secretary Brown. We would have to ship some from the United States, but we certainly do not have enough in the military inventory for that purpose.

Mr. ROGERS. But we do not have enough stockpiled here, do we?

Secretary BROWN. That is correct. We would rely on priority supply of domestic oil as we did in 1973.

Mr. ROGERS. How much do we have in our stockpile at this time?

Secretary BROWN. I would have to recall from memory, which may be wrong. My guess is that we probably have about 30 days in our operating stockpile.

I can supply that.

Mr. ROGERS. I remember the Congress passed a provision that we should have at least 6 months. You have stretched that goal as to 1 year now?

Secretary BROWN. Yes.

Mr. ROGERS. You only have about 30 days?

Secretary BROWN. I believe that is the figure.

Mr. ROGERS. Supply it for the record if you will.

[The information follows:]

PETROLEUM RESERVE INVENTORIES

Neither the Department of Defense nor the nation's commercial oil companies maintain oil inventories designed to augment or sustain supply in the event of a major and protracted interdiction of foreign oil supply. DoD does maintain war reserve stocks to meet surge requirements during the early stages of hostilities when the supply line from commercial sources would be undergoing expansion to sustain wartime consumption rates. Peacetime stocks are maintained at levels adequate to sustain operations between resupply shipments from commercial sources, with small additional safety levels to guard against unforeseen minor interruptions in resupply. Such inventories vary by product and location, but average about 30 days of peacetime consumption. DoD reliance for both wartime and peacetime resupply rests on the output of the commercial refining industry, in the U.S. and abroad. Should total output be inadequate to meet both civil and military needs, whether because of foreign or domestic refining or crude oil supply constraints, DoD would exercise its right to priority supply for essential needs under the Emergency Petroleum Allocation Act or the Defense Production Act.

The commercial petroleum industry generally maintains petroleum inventories adequate to sustain refinery operations, maintain a full distribution system, maintain normal customer supply rates, provide for seasonal buildup of consumption requirements, and provide safety margins against minor unforeseen interruptions in resupply.

Because an adequate reserve inventory to mitigate supply interruptions on the scale of the 1973–1974 embargo or potential larger future military or political supply denials does not exist, the Congress enacted legislation in December 1975 (P.L. 94–163) providing for the establishment of a Strategic Petroleum Reserve to diminish the vulnerability of the United States to the effects of a severe energy supply interruption.

Mr. ROGERS. Let me ask this: What is the Department of Defense doing and what have you been doing as far as research in developing alternative sources and particularly with coal? Have you had a liquefaction program going?

Secretary BROWN. Yes, we have participated.

Mr. ROGERS. What is the result?

Secretary BROWN. Indeed, there has been an experiment in which hydrocarbons liquefied from coal in effect were developed. The Navy has actually run some ships on synthetic fuel created from coal; they found that some adjustments were required but that it could be done.

The problem, as has been the case with most synthetic fuel programs, is that the cost is substantially higher even than the present elevated free market price for oil.

Mr. Rogers. Would you let us know the specifics and details for the record?

Secretary Brown. Yes, I can.

[The following information is submitted for the record:]

Department of Defense Initiatives on Use of Synthetic Fuels in Military Applications

The Department of Defense initial activity in synthetic fuels was begun in FY 1974 when a Memorandum of Understanding (originally between Department of the Interior and the Navy, and now between the Energy Research and Development Administration and the Navy) was developed to provide test quantities of synthetic crudes derived from coal for the Navy to evaluate in ship power plants. ERDA provided the Navy with 1238 bbl of synthetic crude from the Food Machinery Company pilot plant (COED process) in Princeton, N.J., for test and evaluation under a project called SEACOAL. Successful completion of a preliminary test on the distilled crude fuel resulted in a sea-trial demonstration in the U.S.S. Johnston in 1973. Although this particular test was not long enough to fully evaluate the coal-derived fuel, it did demonstrate the potential of using synthetic fuel for naval applications.

In 1976 a T-63 engine was operated on JP-5 jet fuel derived from coal. Engine performance for this test, of 3.6 hours duration, was equivalent to that using JP-5 refined from crude oil. Exhaust emissions of CO, total unburned hydrocarbons and oxides of nitrogen were also equivalent to JP-5 in current use.

U.S. technology for producing liquid fuels from coal appears to be lagging that of other alternatives to crude oil, particularly oil shale. Moreover, because of the high degree of costly hydrotreating required to bring coal liquids into the middle distillate range, economic considerations will most likely direct fuel derived from coal towards the gasoline, boiler utility fuel, and petrochemical feedstock markets. Accordingly, further DoD testing of coal liquids must necessarily await further advances in coal liquid processing technologies leading to the commercial availability of the middle distillate products which are of primary interest to the Department of Defense.

Preliminary tests were conducted in FY 1975 on a synthetic fuel identified as "Unifined Kerosene". Derived from Canadian tar sands, this product met all of the specifications for the Navy's primary jet fuel, JP-5. Aircraft engine tests performed on this fuel indicated no performance or operational differences between the tar sands derived product and conventional JP-5. From a technical viewpoint, tar sands clearly represent a potentially viable source of military fuels even though U.S. tar sand reserves are modest compared to coal and oil shale.

The DoD's most significant participation in a synfuel R&D project to date has been the refining and test and evaluation of fuels produced from 10,000 bbls of shale oil. Based on previous tests conducted by the Bureau of Mines and private shale researchers in the early 1950's, crude shale oil appears to have superior characteristics for the middle-distillate fuels than those derived from coal. The Paraho Oil Shale Demonstration project was organized in 1973 and was completed some three years later. This project was privately financed by 17 participants and the experimental work was conducted on the Naval Oil Shale Reserves at Anvil Points, near Rifle, Colorado, under a lease agreement with ERDA.

Under the joint agency program coordinated by the Navy, approximately 10,000 barrels of crude shale oil produced in the Paraho semi-works plant at Anvil Points were shipped to the Gary Western Refinery to be processed into seven different military and commercial fuels (gasoline, JP-4, JP-5/Jet-A, DFM/DF-2, and heavy fuel oil).

These fuels were then tested at various Government and contractor facilities. The results of these several small-scale combustor and full-scale engine tests clearly established the satisfactory performance characteristics of the shale-derived fuels. These series of tests culminated in the successful operational flight test of a T–39 jet aircraft by the Air Force; the successful operational cruise of the Great Lakes Steamer Edward B. Green, sponsored by the Navy, MARAD, and the Coast Guard; and the operational testing of a jeep (L–141 engine) by the Army. The majority of the fuels produced, however, exhibited certain physical and chemical property deficiencies. Generally, these deficiencies were in the areas of high gum and wax content, high concentrations of fuel-bound nitrogen, and poor thermal and storage stability. Aside from these deficiencies, these tests clearly demonstrated the feasibility of using crude shale oil as a feedstock for military fuels, particularly those in the middle-distillate range (jet and marine fuels).

As a follow-on to the 10,000 bbl shale oil refining and testing project, the Navy in coordination with the Army and Air Force is pursuing a joint DoD/ERDA R&D program for the acquisition, refining, and testing of fuels derived from 100,000 barrels of shale oil to be produced by the Paraho process on the Naval Oil Shale Reserves at Anvil Points, Colorado.

Planning, as originally proposed to ERDA on 15 April 1976, called for $14.2 million to be shared equally between DoD and ERDA. This estimate would allow for the production and refining of 100,000 barrels of shale oil plus an extensive (approximately $1.0 million) ERDA initiative R&D program to assess process variables during the crude shale oil production phase. This proposed joint DoD/ERDA program was agreed to by ERDA on 10 May 1976, subject to Office of Management and Budget (OMB) and Congressional approval of the required reprogramming of ERDA's funding share. Subsequent to OMB review in July 1976, ERDA sought Congressional approval to reprogram $2.4 million of FY 1976 funds in support of this project. In February 1977, the House Subcommittees on Interior and Related Agencies and on Fossil & Nuclear Energy RD&D disapproved this reprogramming request. Navy representatives have subsequently met with ERDA officials and the appropriate members of Congress in an attempt to effect a reconsideration of the $2.4 million reprogramming request as well as to identify and secure the balance of the funds requested from ERDA. As of this date, the extent to which ERDA will provide funding support to this proposed joint effort is uncertain.

To date, the Navy has let approximately $2.1 million in contracts for the refurbishment of the crude shale oil production facility (now complete), the first increment of crude shale oil production (15,000 barrels completed April 1977), and for the erection of 60,000 barrels of additional crude oil storage at the production site (scheduled for completion by 15 May 1977). In addition, the Navy has completed contract negotiations with Paraho to produce an additional 65,000 barrels of crude shale oil and is prepared to fund the next 15,000 barrel production. The present schedule calls for completion of the production phase by 1 June 1978, at which time 100,000 barrels will be available for refining. The ultimate amount of shale oil to be produced and refined will be dependent upon the extent of ERDA funding participation. The refining phase of this project has been initiated with the issuance of a Request For Proposals in March, with the initial bids due on 15 June 1977.

Mr. ROGERS. Finally, what is your projection of use of oil by the Defense Department with the President's program and without the President's program?

Secretary BROWN. We have not made a detailed projection, but I can provide one for you.

Mr. ROGERS. I think that would be helpful.

Secretary BROWN. Yes, sir.

[The information follows:]

FUTURE DOD PETROLEUM CONSUMPTION

DOD projections of petroleum comsumption through Fiscal Year 1978 indicate modest growth of a little more than three percent (about six million barrels) of the Fiscal Year 1976 consumption of about 173 million barrels. Most petroleum is consumed by the operating forces. Significant reductions beyond those already achieved would result in unacceptable degradation of force readiness. That portion of DOD's petroleum use which is attributable to heating and utility fuel for installations and facilities will decline under the President's conservation program.

Presently, the DOD is undertaking a $722 million Energy Conservation Investment Program which will save an estimated energy equivalent of 7.4 million barrels of oil per year at the completion of the program in Fiscal Year 1982. This amounts to 9 percent of the total installation energy consumption in Fiscal Year 1975, the baseline year for Federal energy conservation measurement. DOD achievement of the President's goal for a 20 percent increase in energy efficiency in fixed facilities by Fiscal Year 1985 will require substantial additional investment and will generate an estimated energy savings equivalent to 16.1 million barrels of oil per year. Of that total reduction in energy use, it is estimated that nearly

20 percent, or some 3.2 million barrels, will represent actual reductions in the use of oil, offsetting in part the increases projected for the operating forces.

* * * * * * *

Mr. Moorhead. You spoke about synthetic fuels being more expensive. Yet at a time when we are in a rather precarious position if we would be embargoed again, is it not a good investment perhaps to put money in that area where we have something that we could depend upon if we needed it, and that would give us greater national security in case of war or other emergency than it would be in some other areas?

Secretary Brown. I think that synthetic fuel research and development is a good idea and it probably ought to be expanded somewhat.

* * * * * * *

A Dialogue on Synfuels Between Hon. Joseph L. Fisher and Secretary of Defense Harold Brown, May 4, 1977

Mr. Fisher. The second question is perhaps also somewhere between a question and a suggestion. It relates to synthetic liquid fuel, which has been out in the wings somewhere for almost as long as I can remember but never quite economic to do.

One way is to proceed through offering some kind of subsidy for the erection of synthetic plants.

Another way would be for the Department of Defense to offer long-term contracts for the purchase of synthetic liquid fuel, perhaps on a cost basis, since cost is unknown, and to handle it in this manner. It would not be the first time I guess that the Department of Defense has, in the pursuit of its primary function, been able to do very good deeds for the whole economy. But has thought been given to this as a way of getting into synthetic liquid fuel production?

Secretary Brown. We have, as I indicated earlier, done some experiments using synthetic fuel made from coal and run Navy ships with it. We have not considered, officially, the possibility of the thought that guaranteed purchases at a guaranteed price might be offered, I am less happy with the thought of offering guaranteed purchases on a cost-plus basis because I recall when oil was $2 a barrel and people said if it goes up just a little bit more, we can sell you synthetic fuel at a competitive price. Then it went up to $12 a barrel and they were saying again, if it goes up a little more, we can offer you synthetic fuel at a competitive price. It makes me worry a little bit about how well they know what the price is going to be at which they can produce the fuel.

We know the fuel that was produced in these test runs made by the Navy was enormously expensive. I don't recall the figure, but it is considerably above the world price. However, it was a very limited quantity and the question is, how well can you project much larger plants? That is why I have my worries about it.

Mr. Fisher. I think those are worries that have to be taken account of, but I have always been impressed with the number of good deeds you do for the country in defending it. I don't know how we are going to break over the threshold into synthetic fuels without something like this.

It might be easier to justify it in terms of providing fuel for defense than in any other way. I would urge that it be given thought.

Secretary Brown. It is well worth considering.

ESTIMATE OF NATIONAL HYDROELECTRIC POWER POTENTIAL AT EXISTING DAMS

A Report Submitted to the
President of the United States of America

by the

U. S. Army Corps of Engineers
Institute for Water Resources

Richard J. McDonald
Principal Investigator

July 20, 1977

Rev. 2

SYNOPSIS

On April 20, the President submitted a comprehensive energy plan to the Congress. Included in this plan was the following paragraph:

> New or additional hydroelectric generating capacity at existing dams could be installed at less than the cost of equivalent new coal or nuclear capacity. Many of these sites are small, but could generate 3 to 5 megawatts, and are located near major demand centers currently dependent on imported fuel oil. Installation of additional generating capacity at existing sites could conceivably add as much as 14,000 megawatts to the nation's generating potential.

The fact sheet which accompanied this plan stated:

> The President has directed the Corps of Engineers to report within three months on the potential for additional hydropower installations at existing dams throughout the country -- especially at small sites.

The Corps of Engineers Institute for Water Resources designed a 90-day study to determine not only the physical potential of existing dams but also the constraints to the development of this potential. The results of this study are as follows:

1. By installing more efficient turbines and more powerful generators at existing hydropower dams, 5,100 megawatts of capacity could be obtained.

2. By installing additional turbines and generators to existing hydropower dams, 15,900 megawatts of capacity could be obtained.

3. A maximum of 33,600 megawatts could be obtained by constructing powerhouses at all existing non-hydropower dams in the U.S.

4. There are engineering, economic, financial, environmental, social, and institutional constraints to constructing powerhouses at existing non-hydropower dams. Much of the information needed to determine the precise nature and severity of these constraints is not available, but none are considered to be insurmountable.

5. Additional research, with emphasis on the construction of demonstration small-scale hydropower facilities at a number of existing non-hydropower dams, is recommended as a means to better define the constraints which might hinder and the incentives which might accelerate the development of hydropower at such sites.

Although the total potential for hydropower development is small compared to projected U.S. electric generation needs, hydropower, in conjunction with other evolving energy production systems such as solar, wind, tidal, biomass conversion, geothermal and other small-scale techniques, could provide a significant amount of relief to our current dependence on foreign fossil fuels. The development of all of the hydropower potential at existing hydropower and non-hydropower dams could generate almost 160 billion KWH of electricity and save 727,000 barrels of oil per day. This is seven and one-half times the savings associated with the President's goal of solar heating 2-1/2 million homes by 1985.

TABLE OF CONTENTS

Page

CHAPTER 1 - RESOURCE ASSESSMENT

Summary 1
Overview of Present U.S. Hydropower Development 2
Total Hydropower Potential at Existing Dams 3
Potential at Existing Dams Over 5,000 KW 3
Potential at Existing Dams Less Than 5,000 KW 5
Regional Analysis 6

CHAPTER 2 - CONSTRAINTS TO HYDROPOWER DEVELOPMENT AT EXISTING DAMS

Introduction 11
Engineering Constraints 11

Hydropower Engineering Considerations 11
Rehabilitation Considerations 12
Network Technology Considerations 13

Economic Feasibility Constraints 13
Environmental Considerations 16
Social Aspects 16
Institutional and Legal Implications 18

CHAPTER 3 - RECOMMENDATIONS

Demonstration Studies 19
Review of Constraints and Suggested Approaches 20

APPENDIX A Hydropower Estimation Procedure for Small Dams A-1

APPENDIX B Regional Hydropower Potential Statistics B-1

APPENDIX C Existing Regional Reservoir Storage C-1

LIST OF FIGURES

Figure

1 Trends in Developed Hydroelectric Capacity 2

2 Conventional Hydroelectric Capacity (Constructed and Potential) at Existing Dams 7

LIST OF TABLES

Table		Page
1	Conventional Hydroelectric Capacity (Constructed and Potential) at Existing Dams	1
2	Potential at Existing Dams Greater than 5,000 KW Capacity	5
3	Conventional Hydroelectric Capacity Potential at Existing Dams	8
4	Conventional Hydroelectric Energy Yield Potential at Existing Dams	9
5	Maximum Potential Deferment of Expected Steam-Electric Growth between 1975-1985	10
6	Retired Hydropower Capacity	13
7	National Use of Existing Reservoir Storage	15
A-1	Prototype Dam Characteristics	A-3
A-2	Continuous Flow Factors	A-4
A-3	Plant Factors	A-5
B-1 thru B-21	Regional Hydropower and Hydropower Potential Statistics	B-2 thru B-22
C-1 thru	Existing Regional Reservoir Storage Statistics	C-2 thru C-22

PREFACE

This report was prepared by the Corps of Engineers in response to a Presidential request to determine the potential for additional hydropower installations at existing dams throughout the United States--especially at small sites. The results are based on published reports and special studies supplied by the Federal Power Commission and on an intensive 90-day study by the Corps' Institute for Water Resources and the 47 Corps Division and District offices throughout the country.

The objectives of this study are threefold:

1. Estimate the maximum potential conventional hydropower capacity and electricity output which could be developed at existing dams in the United States.

2. Identify the constraints which might hinder or prevent the development of this potential.

3. Identify the means which could be employed to resolve or relax these constraints and the incentives which might be used to spur the development of this potential.

The report is organized into three chapters corresponding to the three objectives plus three appendices. Appendix A contains a detailed description of the method used by the Corps to estimate hydropower potential at existing small dams. Appendix B contains supplemental information on the hydropower potential for each of the 21 major drainage basins in the U.S., Alaska, Hawaii, Puerto Rico, and the Virgin Islands, including a summary of the engineering characteristics of the existing dams in each region. Appendix C contains regional statistics on current competing uses of existing reservoir storage space.

CHAPTER 1

RESOURCE ASSESSMENT

Summary

At the present time, the total maximum potential conventional hydroelectric capacity at existing dams, both developed and undeveloped, is 119.8 million kilowatts capable of generating an average of about 447.1 billion kilowatt-hours annually. Approximately 57.0 million KW, or 47.6 percent of existing dam potential has already been developed. Another 8.2 million KW of capacity is currently under construction. The remainder (54.6 million KW) is the maximum potential capacity which could be achieved by upgrading and expanding existing hydropower dams and by adding hydropower facilities to all existing large and small dams in the United States.

Table 1

Conventional Hydroelectric Capacity
(Constructed and Potential) at Existing Dams

	Capacity (Millions of KW)	Generation (Billions of KWH)
Developed	57.0	271.0
Under construction	8.2	16.8
Total Installed	65.2	287.8
Potential rehabilitation of existing hydro dams	5.1	24.4
Potential expansion of existing hydro dams	15.9	29.8
Potential at existing non-hydro dams greater than 5,000 KW	7.0	20.4
Potential at existing non-hydro dams less than 5,000 KW	26.6	84.7
Total Potential	54.6	159.3
TOTAL (Developed and Undeveloped)	119.8	447.1

Overview of Present U.S. Hydropower Development

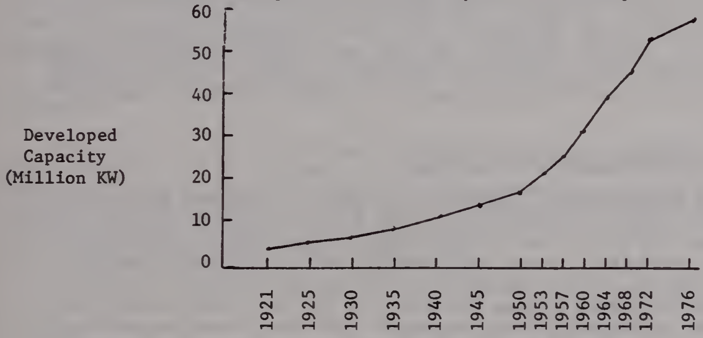
As of January 1, 1976, there were approximately 1,400 conventional hydroelectric power plants in the United States with a total installed generating capacity of 57 million kilowatts (KW). In addition, there were 11 new facilities and 17 expansions under construction with a design generation capacity of 8.2 million KW.[1] Including the expected output of facilities currently under construction, the annual average electricity production from conventional hydropower plants is 287.8 billion kilowatt hours (KWH), compared to a total U.S. electricity production of about 2,000 billion KWH in 1976.

The installed conventional hydroelectric capacity in the country tripled between 1921 and 1940, nearly tripled again between 1940 and 1960, and will double again between 1960 and 1980. However, much of the recent growth in capacity results from the construction and operation of pumped storage plants. Pumped storage plants are a special type of hydroelectric facility which are not included in the statistics reported in this study, since the physical potential for pumped storage is virtually unlimited.

The continuing growth in hydroelectric capacity has been overshadowed by a faster rate of expansion of steam-electric generating capacity. In the 1920's conventional hydroelectric plants provided as much as a third of the total generating capacity of the United States. They now contribute only about 13 percent of the U.S. electricity requirements.

Figure 1

Trend in Developed Conventional Hydroelectric Capacity



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[1] Federal Power Commission, "Hydroelectric Power Resources of the United States," U.S. Printing Office, Washington, D.C., January 1, 1976

Total Hydropower Potential at Existing Dams

The maximum potential for conventional hydroelectric development at existing dams in the United States is 54.6 million kilowatts (KW), with an expected production of 159.3 billion kilowatts-hours (KWH) of electric energy per year. The complete development of this amount of capacity and generation could defer 15.3 percent and 8.65 percent of the projected growth in steam-electric capacity and generation during the period 1975-1985.[2] Using the commonly accepted ratio of 1 barrel of oil = 600 KWH at the point of consumption, the complete development of all hydropower potential at all existing U.S. dam sites represents a savings in oil consumption equivalent to 727,000 barrels per day.

This estimate of conventional undeveloped water power is an upper bound on the physical potential for hydroelectric development at 49,500 existing dams in the United States. The estimate does not include detailed consideration of engineering, economic, financial, or environmental feasibility; it does not consider the competitive use of water impounded by these dams; and it does not include consideration of the many institutional and legal problems which must be overcome to fully develop this energy resource. Considerations of these factors will undoubtedly place limits on the amount of this potential which can be justified. On the other hand, this estimate does not include an important factor which could increase this potential, namely, operating series of dams as systems to increase the potential of each individual dam.

The derivation of the national estimate relies on two sources: (1) the Federal Power Commission publication entitled "Hydroelectric Power Resources of the United States - Developed and Undeveloped," dated January 1, 1976; and (2) a special study performed by the Corps of Engineers between April and July 1977. The FPC inventory contains estimates of hydropower potential at dams or sites with a capacity of 5,000 KW or greater. The Corps study was thus directed toward existing dams with capacity potential less than 5,000 KW.

Potential at Existing Dams over 5,000 KW

The FPC systematically compiles statistics on hydropower potential for dams on sites over 5,000 KW capacity using data from Federal and State river basin studies and project feasibility reports, from studies performed by industry and private utilities, and from applications for FPC licenses. Where such studies are not available, and potential is known to exist at a site, the FPC estimates average streamflow at the site, the actual or expected amount of hydraulic head, assumes an efficiency based on the type of turbine which is likely to be installed, and computes hydropower potential. The determination of nameplate capacity and of actual electricity produced in KWH is based on an assumed operation mode for the power plant, which in turn is based on the ability of the dam to supply either base load or peak load power.

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[2] U.S. Water Resources Council, "Water for Energy," draft report, February 1977, pp A-6 to A-27

The FPC estimates are site-specific, are usually based on a preliminary assessment of engineering, economic, and financial feasibility, and frequently include some consideration for current and projected needs for flood control, water supply, navigation, and other non-hydropower reservoir storage uses.

The Corps performed a special study to determine the proportion of hydropower potential for dams listed in the FPC inventory which can be attributed to existing dams as opposed to undeveloped dam sites. The potential at listed hydropower dams which could be expanded to include additional turbines and generators is 15.9 million KW and 29.8 billion KWH. The potential at listed non-hydropower dams which could be retrofitted with a powerhouse is 7.0 million KW and 20.4 billion KWH. No data for the expansion potential of existing hydropower dams below 5,000 KW rated capacity were available.

In addition to expansion potential, many existing hydropower plants could be renovated with more efficient turbines and more powerful generators. This potential for hydropower development has also been included in the national estimate. A recent GAO report[3] concludes that the capacity and electricity generation of existing Federal hydropower dams could be increased between 1 and 10 percent by installing new turbines and generators and by replacing old and worn components. Efficiency increases which averaged 9 percent were cited for 7 recent U.S. and Canadian public power plant rehabilitation projects. It is assumed that both public and private power dams in the U.S., particularly older dams, could be similarly fitted with new turbines and generators. Applying an average increase in efficiency of 9 percent to approximately 1,400 existing hydropower facilities produces an additional hydropower potential of 5.1 million KW and 24.4 billion KWH of generation.

To summarize, if all existing hydropower plants over 5,000 KW capacity were rehabilitated, if existing hydropower dams with expansion potential were enlarged, and if all identified existing non-hydropower dams with hydropower potential over 5,000 KW were fitted with conventional turbines, national electricity capacity and generation could be increased by 28.0 million KW and 74.6 billion KWH, respectively.

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[3] U.S. General Accounting Office, "Power Production at Federal Dams Could be Increased by Modernizing Turbines and Generators," Case No. OSD 4587 March 16, 1977.

Table 2

Potential at Existing Dams Greater than 5,000 KW Capacity

	Capacity (Million KW)	Output (Billion KWH)
Increase due to rehabilitation of existing hydropower dams	5.1	24.4
Expansion of existing hydropower dams	15.9	29.8
Installation of hydropower at existing non-hydropower dams	7.0	20.4
TOTAL	28.0	74.6

Potential at Existing Dams Less than 5,000 KW

The remainder of the national estimate for hydropower potential at existing dams is due to the developable capacity at existing small dams, defined as dams less than 100 feet in height, less than 10,000 acre-feet of reservoir storage capacity, and with a potential capacity less than 5,000 KW.

The Corps estimate of national hydropower potential at existing small dams is 26.6 million KW, with a potential energy yield of 84.7 billion KWH. Due to the short time duration of the study, it was not possible to compute the power potential at each of the individual small dams in the U.S. Instead, the following method was used:

1. Existing small dams in each river basin were grouped into categories with similar hydraulic head and reservoir storage characteristics.

2. Each river basin was partitioned into streamflow zones.

3. Typical dams from each of the small dam categories were allocated to appropriate streamflow zones.

4. The maximum power potential for each typical dam was determined by using average streamflow, maximum hydraulic head, maximum use of reservoir storage for power production, and maximum efficiency parameters in the hydropower formula $(P = \frac{Qhe}{11.8})$.

5. The energy potential of a dam was determined by adjusting power potential to account for the dependability and variation of streamflow in each streamflow zone.

6. Design capacity was determined by assuming the most likely operating mode for each typical dam based on the relationship between usable streamflow and reservoir storage.

7. Energy and capacity figures for each typical dam were multiplied by the number of dams in each category to compute the total electrical generation and capacity potential of all existing small dams in a basin.[4]

This method was applied by planners and engineers in each District office to river basins within their jurisdiction. Knowledge of unique local factors which might affect streamflow or the distribution of existing dams was fully utilized in determining streamflow zones and allocating representative dams to the various zones. This analytical approach, which merges a technically sound estimation procedure with field-based expertise and experience, provides a reasonable estimate of maximum physical hydropower potential.

Regional Analysis

Figure 2 and Tables 3 and 4 contain statistics on, the distribution of hydropower potential at existing dams for each of the 21 major drainage areas of the United States.

The hydropower potential at existing dams varies widely throughout the nation. The physical factors which create regional hydropower potential (amount of precipitation runoff, number of existing dams, and topographic relief) vary considerably between the Northwest, the Eastern Seaboard, the Great Plains, and the Southwest. The Pacific Northwest has both the largest installed capacity and the largest hydropower potential of any major river drainage area in the U.S. This region alone has almost as much capacity potential as all the regions west of the Appalachians and east of the Sierra Mountains combined, and would probably have more potential than the U.S. Midlands if the region had the same proportion of small dams per square mile of drainage area commonly found in more densely settled and more extensively developed areas in the East and Midwest.

For the remainder of the regions, hydropower potential is fairly proportional to the size of the region, with large regions (Mid-Atlantic, South Atlantic-Gulf, Ohio River, etc.) exhibiting large potential and small drainage basins (such as Hudson Bay and Hawaii) with small potential. Notable exceptions are the large regions in the Southwest (Texas-Gulf, Rio Grande, Colorado, and the Great Basin) where arid conditions and low streamflows are prevalent.

Table 5 shows the expected growth in regional steam-electric capacity and generation between 1975 and 1985 for each major river drainage and the percentage which could be deferred by the full development of hydroelectric power at existing dams. Nationally, the maximum development of hydropower at existing dams could defer 15.4 percent of expected capacity growth and 8.6 percent of generation growth, with the most significant effects occurring in the Columbia-Northwest Pacific, New England, Mid-Atlantic, Upper Mississippi, Lower Mississippi, and Alaska regions. The New England potential is particularly important because of the region's relatively high electricity costs and its dependence on foreign crude oil.

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[4] An expanded explanation of the methodology is contained in Appendix A of this report.

Figure 2

Conventional Hydroelectric Capacity
Potential at Existing Dams

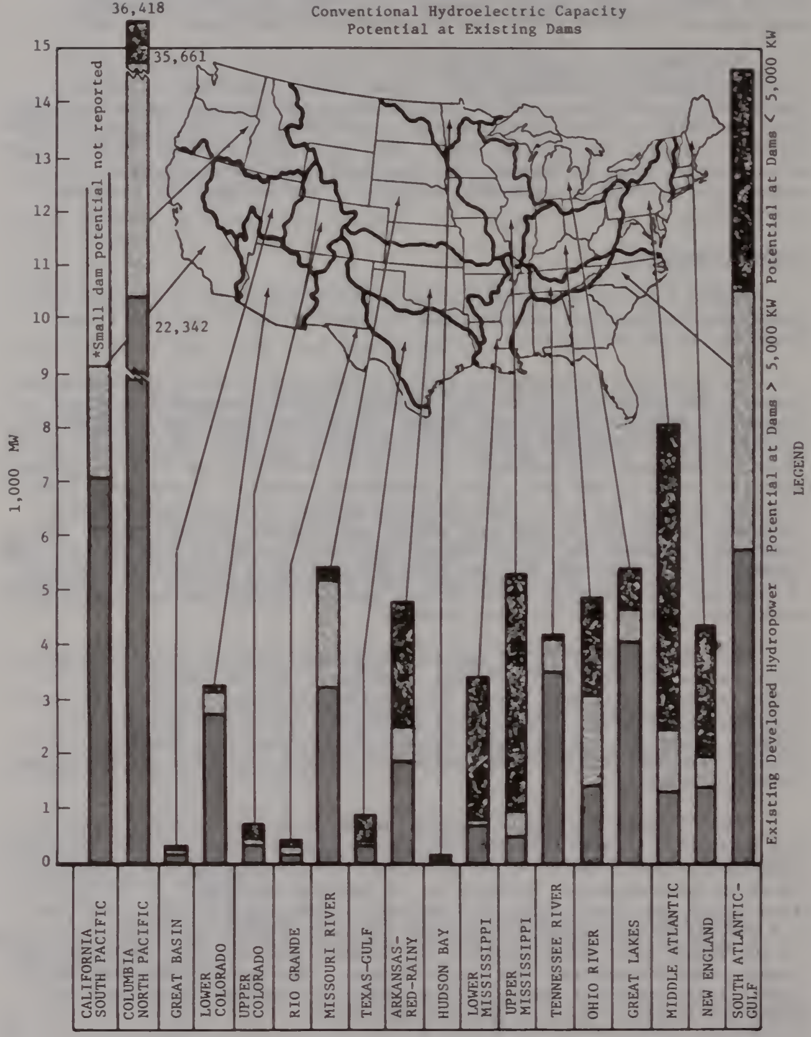

Table 3

Conventional Hydroelectric Capacity Potential at Existing Dams

	Existing Capacity (MW)	Rehabilitation Potential (MW)(9%)	Hydro Expansion Potential (MW)	Hydro Installation Potential (MW)	Small Dam Potential (MW)	Total Regional Potential (MW)
New England	1,427	127	188	223	2,432	2,970
Mid-Atlantic	1,290	116	565	521	5,580	6,782
South Atlantic-Gulf	5,753	518	3,342	874	4,244	8,978
Great Lakes	4,008	360	253	143	644	1,400
Ohio River	1,465	132	19	1,414	1,873	3,438
Tennessee River	3,658	329	30	0	75	434
Upper Mississippi River	581	52	80	199	4,378	4,709
Lower Mississippi River	724	18	88	25	2,582	2,713
Hudson Bay	13	1	0	0	51	52
Arkansas-White-Red River	1,839	165	236	245	2,318	2,964
Texas-Gulf	393	35	11	43	460	549
Missouri River	3,370	303	1,037	486	250	2,076
Rio Grande River	65	6	20	130	184	340
Upper Colorado River	359	32	15	24	465	536
Lower Colorado River	2,847	256	0	59	87	402
Great Basin	530	48	1	0	85	134
Columbia-North Pacific	22,342	2,010	10,681	628	757	14,076
California-South Pacific	7,050	634	970	514	*	2,118
Alaska	123	11	36	46	25	118
Hawaii	18	2	1	0	30	33
Puerto Rico	0	0	0	0	10	10
Virgin Islands	0	0	0	0	0	0
TOTALS	57,855	5,155	17,573	5,574	26,530	54,832

* No estimate was available for the California-South Pacific Region

Table 4

Conventional Hydroelectric Energy Yield Potential at Existing Dams

	Existing Energy Yield (10^6 KWH)	Rehabilitation Potential (9%)	Hydro Expansion Potential	Hydro Installation Potential	Small Dam Potential	Total Regional Potential (10^6 KWH)
New England	5,719	515	502	517	11,685	13,219
Mid-Atlantic	5,201	477	1,945	792	15,279	18,493
South Atlantic-Gulf	14,521	1,307	9,228	1,255	21,846	33,636
Great Lakes	24,754	2,228	578	580	2,423	5,809
Ohio River	5,505	495	100	4,680	2,849	8,124
Tennessee River	16,112	1,450	139	0	371	1,960
Upper Mississippi River	3,006	270	260	1,077	8,991	10,598
Lower Mississippi River	424	38	136	104	8,110	8,388
Hudson Bay	68	6	0	0	72	78
Arkansas-White-Red River	5,019	452	269	322	6,525	7,568
Texas-Gulf	1,074	97	6	61	1,095	1,259
Missouri River	15,294	1,376	4,632	1,106	580	7,694
Rio Grande	234	21	49	311	788	1,169
Upper Colorado River	1,634	147	80	49	593	869
Lower Colorado River	10,541	579	0	289	526	1,394
Great Basin	1,976	178	1	0	179	358
Columbia-North Pacific	127,182	11,446	14,865	2,949	2,495	31,755
California-South Pacific	33,400	3,006	3,264	2,304	*	8,574
Alaska	493	44	141	239	112	536
Hawaii	104	9	8	0	40	57
Puerto Rico	0	0	0	0	129	129
Virgin Islands	0	0	0	0	0	0
TOTALS	272,261	24,141	36,203	16,635	84,688	161,667

* No estimate was available for the California-South Pacific Region

Table 5

Maximum Potential Deferment of Expected Steam-Electric Growth between 1975-1985 by Full Development of Hydropower at Existing Dams

River Region	Projected Steam-Electric Growth (1975-1985)		Percentage of Possible Deferment by Hydropower Development at Existing Dams	
	Capacity (million KW)	Generation (billion KW)	Capacity	Generation
New England	8.49	53.2	35.0%	24.8%
Mid Atlantic	28.32	170.7	24.0%	10.8%
South Atlantic - Gulf	85.82	396.5	-10.5%	-8.5%
Great Lakes	23.12	155.7	6.1%	3.7%
Ohio River	39.88	183.65	-8.6%	-4.4%
Tennessee River	16.96	65.74	2.6%	3.0%
Upper Mississippi River	24.14	132.97	19.6%	8.0%
Lower Mississippi River	13.01	67.10	20.7%	12.5%
Hudson Bay	-0.4	-0.5	See Footnote	See Footnote
Arkansas-White-Red River	20.89	111.40	14.2%	6.8%
Texas - Gulf	31.28	146.81	1.7%	0.9%
Missouri River	22.18	118.83	9.3%	6.5%
Rio Grande	0.11	-1.05	See Footnote	See Footnote
Upper Colorado River	8.00	34.15	6.7%	2.5%
Lower Colorado River	5.64	31.74	-7.1%	-4.4%
Great Basin	3.5	20.55	-3.8%	1.7%
Columbia - North Pacific	6.37	41.60	100.0+%	76.0%
California - South Pacific	13.51	87.73	15.6%	9.7%
Alaska	0.25	1.14	47.1%	47.0%
Hawaii	1.03	5.1	3.2%	1.1%
Puerto Rico - Virgin Islands	3.80	17.26	0.3%	0.7%
TOTAL	355.90	1,840.31	15.4%	8.8%

*Imported electricity from outside the region are predominate, thus deferment figures are not applicable here.

CHAPTER 2

CONSTRAINTS TO HYDROPOWER DEVELOPMENT AT EXISTING DAMS

Introduction

Chapter 1 contains summary statistics of maximum physical hydropower potential at existing dams for each region of the U.S. and for the nation. In this chapter the constraints which will inhibit the full development of hydropower at existing dams will be described. The barriers to large-scale hydropower development and to small-scale hydropower development at existing dams are similar, but small-scale development involves unique considerations which have not previously been documented. Therefore, although the following discussion applies to both categories, the emphasis will be on constraints to small-scale development.

The conversion of hydropower potential into electricity on line is subject to a number of engineering, financial, legal, institutional and other considerations. An exhaustive study of each of these considerations is necessary before the overall feasibility of hydropower development at existing dams can be precisely determined. Within the limitations of this 90-day study, it is possible only to (1) assess the type of considerations which might constrain hydropower development; (2) analyze in general their possible nature and significance, and (3) formulate general approaches to further detailed investigations of potential constraints.

1. Engineering Constraints

Engineering factors relevant to this review include: (a) engineering techniques for designing small powerhouses and low head/low-flow turbines; (b) the difficulty and cost of rehabilitating existing dams; and (c) design of electricity delivery systems which integrate small-scale hydropower production into a regional or area supply network.

(a) Hydropower engineering considerations.

A hydraulic turbine operates according to effective hydraulic pressure and quantity of water flow. The absolute lower limit at which a turbine will operate efficiently is not known, but 16,700 of the dams analyzed during this study (34 percent of the existing dams in the U.S.) have hydraulic heads of only 6 to 20 feet.

A comprehensive study of the electro-mechanical technology of small-scale powerhouse and turbine design was not performed for this study. It is reported[5] that European and Asian engineers are routinely designing and constructing small-scale hydropower turbines and generators. Only one large company and several small firms in the United States have designed, constructed, and installed small-scale hydropower facilities. The reason for the low level of U.S. design and manufacturing activity is the lack of interest in and demand for small-scale hydropower prior to recent fossil fuel price increases. Based on the presumed success of overseas installations, there should be no insurmountable electro-mechanical design problems.

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[5] A recent issue of Engineering News Record magazine (June 2, 1977, p 8) reports that there are 40 European manufacturers of small turbines. The article also states that the USSR reportedly builds turbines as small as 5 kilowatts design capacity.

However, an active program in small-scale hydropower development would require simplified planning techniques to determine the capacity and energy yield at potential small-scale hydropower sites. The current practice of custom designing the hydropower facilities at each individual hydropower site would prove too cumbersome and too expensive. Given a demand for small-scale hydropower development, it is likely that planning and design techniques could be readily derived.

(b) Rehabilitation considerations.

Many of the dams included as potential power producers are very old and may be in need of extensive rehabilitation. Many earth and rockfill structures have effective lives of 100 years or more, but concrete dams (gravity, buttress, arch, and multi-arch dams) begin to display serious evidence of stress and decay after 50 years. Of the dams listed in the Corps inventory, 8,100 (16.4 percent) were constructed before 1930 and of these, 2,200 are concrete dams. Assuming prohibitive rehabilitation costs for half of the concrete dams built prior to 1930, the estimate of hydropower capacity and generation would be reduced by 1.8 million KW and 5.7 billion KWH, respectively. The reduction would be greatest in the New England, Mid-Atlantic, and Ohio regions, where old concrete dams comprise 27 percent, 13 percent, and 20 percent of the regions' dams respectively.

Reservoir storage capacity is also a function of the age of a dam. On the high silt load streams in the Midwest and West, all types of dams will have lost much of their effective storage capacity and regulation capability after 50 years. Assuming that half of the 2,185 pre-1930 dams in the seven Midwest and Southwest regions retain only 50 percent of their effective storage capacity, the regional estimate of hydropower capacity and generation for these seven regions would be reduced 1.0 million KW and 2.6 billion KWH, respectively.

The above assumptions regarding the extent of needed rehabilitation and lost storage are necessary because more precise information is not available. A preliminary engineering feasibility study of the nation's inventory of existing dams is required both to more precisely define energy potential and to determine the overall safety and reliability of many potential hydropower installations. Furthermore, it is likely that many hydropower conversions would involve raising the height of dams to capture additional hydropower storage. Adding new stresses to old dams is a significant factor for consideration in any small-scale hydropower development program.

(c) Network technology considerations.

It is difficult for a utility engineer to design power plants and power transmission systems capable of meeting demand for electricity if a substantial part of the capacity is subject to the vagaries of nature. Modern high-speed computers and complex system interties are invaluable in matching demand with supply, but even in a system dominated by large steam-electric plants where fuel inputs can be completely controlled, occasional shortfalls occur and are difficult to adjust for.

Network considerations involve the reliability of power produced by small dams. Approximately 30,100 (60.8 percent) of the 49,500 dams in the U.S. are located on streams which dry up from 1 week to 6 months almost every year. These dams have been included as potential energy producers even though standard analysis procedures which use firm yield (or constantly reliable streamflow) as a basis for estimating potential would result in zero capacity for these dams. Dams of this type, located in intermittent or frequent-zero streamflow zones, have a reported capacity of 1.4 million KW and an expected generation of .83 billion KWH per year. Finally, many of the dams in the inventory are constructed in remote locations which would require the construction of inordinately expensive transmission lines. The data to estimate the reduction in capacity and generation due to this factor are not available.

2. Economic Feasibility Constraints

The economics of small-scale hydropower development is one of the most significant of all of the constraints discussed in this chapter. On the one hand, logic leads to the conclusion that if hydropower at new sites is already competitive with alternative energy sources in many regions of the country, then hydropower at existing dams must be even more competitive because the capital cost of constructing the dams is a sunk cost. On the other hand, if hydropower at existing dams is cost competitive, one might expect at least a modicum of activity by public and private utilities and industry to develop this resource for profit. Yet a recent survey of 30 utilities[6] shows only a few are even remotely interested in hydropower, much less small hydropower development. In fact, prior to the recent oil embargo, small hydropower plants were still being retired at a regular rate.[7]

Table 6

Retired Hydropower Capacity

Time Period	Retired Capacity (KW)
1940-1950	104,360
1951-1960	87,152
1961-1970	238,747
1970-1976	146,944

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[6] Engineering News Record, June 2, 1977, p 6.

[7] FPC

A few generalizations are possible with respect to the relative economic and resource efficiency of hydropower. In terms of economic efficiency, hydropower has several general inherent advantages over thermal power. The useful life of structures is two to three times longer than thermal plants and equipment, hydropower consumes no fuel (a major cost item for thermal power generation), operation and maintenance costs are lower because equipment is less complex, and hydropower is capable of almost instantaneous response to increased load demands.

These inherent advantages have historically been offset by the fact that initial investment costs per unit of capacity have been greater for hydropower than for thermal plant and equipment. But this advantage is now being narrowed by the sharp increases in fuel costs and investment costs associated with the siting and construction of fossil fuel and nuclear plants, including cost increases associated with equipment and operating costs for air and water pollution control. For example, a recent MITRE Corporation study of electrical generation costs in New England concludes "...in 1955, to develop a potential hydro site at a .7 plant factor, a private utility could afford to spend a maximum of about $825/KW in 1975 dollars ($291/KW in 1955 dollars); by 1981 the utility can spend up to $1,490/KW in 1975 dollars ($1,997/KW in 1981 dollars). In short, many sites which were formerly uneconomic may now be competitive."[8]

The traditional advantage of steam-electric power is narrowed, and perhaps reversed, for hydropower development at existing dams, since the capital costs of constructing the dam have already been made. However, in the case of hydropower development at existing dams, the assumption of zero cost for the "fuel" (water) which powers the turbine is no longer applicable. Almost all existing reservoir storage is currently being used for some productive or socially important purpose. Reservoir space is used to store municipal, industrial, and agricultural water supplies, for navigation, flood control, water quality control, and recreation, as well as for hydropower production. Some uses are not competitive, as in the case of reservoir releases for downstream water quality control which can be passed through a turbine without loss of function. However, reservoir space reserved for flood waters cannot be simultaneously used to store hydropower water. Water supply storage, if used for hydropower production, must be eventually replaced by water pumped back to the level of water intakes with a net loss in energy. The large fluctuations in releases to meet peak demand requirements often conflict with the recreation objective both on the reservoir surface and on the stream below the dam.

Table 7 contains a summary of information on the primary use of the storage behind the 49,500 dams in the Corps inventory. This table does not distinguish between single-purpose and multiple-purpose projects and does not reflect the extreme variation of reservoir use between various regions. The predominant use of reservoir storage in each major drainage area is shown in Appendix C.

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[8] P.R. Vance and L.C. Bryan, "Hydro Power: Economic Comparisons," MITRE Technical Report MTR-3394, December 30, 1976, p 15.

Table 7

National Use of Existing Reservoir Storage

Primary Purpose	Number of Dams	Total Maximum Storage (Millions of Acre-Feet)
Irrigation	6,329	150.083
Hydroelectric	1,372	167.768
Flood Control	7,776	300.678
Navigation	187	125.355
Water Supply	7,279	267.187
Recreation	16,639	263.986
Debris Control	344	190.907
Farm Ponds	4,546	197.796
Other	4,779	111.456

The FPC estimate of hydropower potential at larger dams includes some consideration for competitive use of storage, but the Corps estimate for existing dams below 5,000 KW capacity assumes that all existing reservoir storage would be converted to hydropower storage and used to produce electricity. This would obviously create considerable economic disruption in many cases. For example, the Occoquan reservoir in Northern Virginia annually supplies 58 million gallons per day of water to Washington metropolitan area customers, yielding $12 million in gross revenues.[9] In the FPC inventory, this same dam, raised to provide a hydraulic head four times greater than now exists, would have a rated capacity of 17,500 KW capable of producing 47 million KWH of electricity per year. At current average household utility rates in Northern Virginia ($0.039/KWH)[10] the financial yield from this reservoir would be only $1.8 million. On the other hand, one of the current water problems in the West is the ability of electricity companies to outbid irrigators for scarce water supplies. In this case, although the transfer of water from irrigation to hydropower may be economically efficient, the economic impacts would be severe to the many small farmers in the region.

It is possible to estimate the magnitude of the reduction in estimated capacity caused by competitive demand for reservoir storage if it is assumed that the U.S.G.S. streamflow estimates already fully account for the effects of current reservoir operations and withdrawals. All average annual streamflow would thus be available for power production. Omitting the reservoir drawdown component from the flow used to calculate small dam hydropower potential results in a reduction of about 18 percent (9.3 million KW of capacity and 30 billion KWH of generation) to the national estimates.

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[9] Telephone communication, Fairfax Water Authority, June 1977.

[10] Telephone communication, Virginia Electric Power Company, June 1977.

3. Environmental Considerations

The environmental implications of the development of hydropower resources must be viewed in terms of the overall quantitative relationship of hydropower to total electrical energy needs. It is evident that even the total development of hydropower resources at existing dams is not an alternative to the extensive development of other indigenous resources such as coal, natural gas, petroleum, geothermal energy and nuclear power. Hence, the effectiveness of hydropower development in preventing or mitigating the environmental consequences of fossil fuel or nuclear plants is limited.

Existing dams which have been in place a long time have become ecologically stable; i.e., both water and adjacent land flora and fauna have adjusted to the presence of the reservoir and the substitute ecologic network now depends on its existence. The best retrofit condition, from an ecologic point of view, would involve a simple rerouting of normal reservoir discharge through a turbine. This is identical to a "run-of-the-river" mode of operation.

However, the most economically efficient use of many hydropower dams would be for peak load power, where the reservoir is essentially the hydraulic equivalent of a storage battery which accumulates energy most of the time and is rapidly dumped during periods of peak energy demand. Most of the existing dams in the U.S. do not have sufficient storage for peak load operation and would have to be used in a "run-of-the-river" mode. But dams with peak power capability, if converted to such use, would be subject to frequent filling and drawdown of their reservoirs with attendant large variations in downstream flows which might cause serious environmental, ecologic, and aesthetic impacts.

The Corps analysis of small dams indicates that 19.6 million KW of capacity and 45.7 billion KWH of generation is attributed to dams which would probably be operated for peak load power. It can be assumed that at least the same percentage of potential for dams in the FPC inventory would also be for peak power production. Thus the environmental constraint may reduce the national estimates by as much as 24.8 million KW and 56.7 billion KWH of generation.

It may be that the environmental impacts of small-scale peak load hydropower plants are highly localized and relatively insignificant. However, more comprehensive environmental analysis, using data from existing small-scale hydropower installations, would be required before the economic and environmental trade-offs of peak power generation could be determined.

4. Social Aspects

An assessment of the social effects of water development decisions has become an integral part of the water resources planning process. The effects of a small-scale hydropower development program must take into account the impact on individual consumers of electricity, the community structure and order, and a concern for national social well-being.

Within the limited time and objectives of this study, it is only possible to determine some of the more obvious social ramifications of small-scale hydropower development. These include:

- possible conflicts associated with reallocating reservoir storage from any other purpose to hydropower. Such a change could shift the incidence of project benefits from one group to another and cause a possible redistribution of income in nearby communities.
- possible health and safety considerations. A local dam may be either more or less hazardous after conversion to hydropower, depending on the care with which renovation is undertaken. Some safety effects may also apply to downstream in-stream users (such as boaters or fishermen) due to changes in the operation of a dam, particularly if the dam is used for peak load power.
- possible effects on community cohesion. The decentralization effect caused by a shift from a large and remote steam-electric plant to a nearby hydropower dam may have a positive effect. Decentralization of energy resources would allow individual communities to have more control over electricity supplies. The energy crisis would be perceived as a problem which the community could collectively confront by establishing operating policies for its hydropower resources. This is especially true if reimbursement for power delivered outside the community is available.
- possible effects on attitudes toward energy conservation. Because small-scale hydropower is so susceptible to variations in rainfall and streamflow, dependence on a local hydropower plant would lead to increased sensitivity to the waste of electricity, especially during dry periods of the year.
- possible effects of the uneven reliability of small-scale hydropower. Inevitably, a power system based on a significant amount of small-scale hydropower will experience a shortfall due to short-term and long-term droughts. A serious hazard situation may be created if power shortages coincide with times of community crisis (say a major fire).

The effects listed above are only a few of the many social ramifications of small-scale hydropower development. It is a difficult task, but perhaps the most important one of all, to unravel the innumerable possible social and psychological consequences prior to a significant national effort to develop small-scale hydropower at existing dams.

5. Institutional and Legal Implications

Only 5,500 of the 49,500 dams in the United States are owned and operated by the Federal Government. The remainder are owned by state and local governments, by public and private utilities, by industries and private corporations, and by individuals. Each class of potential hydropower developer operates within a particular set of institutional constraints imposed by (1) regulatory agencies at all levels of government; (2) riparian or appropriation water laws; (3) individual, community, or corporate goals, values, beliefs, mores, and customs; (4) existing treaties, state constitutions, local charters, ordinances, and municipal by-laws; (5) a unique economic and financial environment; and (6) conflicts between short-range and long-range organizational and individual objectives.

Because such a large proportion of existing dams are owned by nonfederal interests, the role of the Federal Government in development of small-scale hydroelectric projects becomes supportive, consultative, and facilitative in nature, as opposed to the traditional federal role as the dominant institution in water resources development. The Federal Power Commission plans to streamline its license application procedure for small-scale hydropower plants to simplify the procedure and thereby reduce the time required to obtain a license. The Energy Research and Development Administration is initiating a research, development and demonstration program in small-scale hydropower development to alleviate some of the uncertainty of nonfederal interests toward the overall feasibility of such installations.

These are some of the necessary first steps toward developing an integrated system of Federal incentives and policies which encourage the private development of small-scale hydropower projects. Future actions must deal not only with the Federal sector, but also identify and alleviate the many nonfederal legal, regulatory, and financial barriers which could retard or prevent the timely development of small-scale hydroelectric potential at existing dams.

CHAPTER 3

RECOMMENDATIONS

Demonstration Studies

The principal conclusions of this study are that none of the identifiable constraints to the development of hydroelectric power at existing dams are insurmountable and that the national potential is of such significance to warrant the rapid selection and development of small-scale hydropower demonstration projects. Demonstration projects constitute the best means of developing the additional data needed to better assess the engineering and economic feasibility of a small-scale hydropower development program. At least a few of the demonstration projects should be at retired hydropower sites, since these dams offer the best opportunity to quickly and inexpensively construct prototype powerhouses and concentrate effort and funds on important technological considerations.

The FPC has provided the Corps with a list of 771 hydropower plants which have been retired from service since 1940. The largest of the plants, at sites which may be susceptible to rehabilitation, are:

Name	Listed Owner	River and State	Capacity (KW)
Riley Mill	International Paper	Androscoggin, Maine	5,400
Lowell	Merrimack Mfg Co.	Merrimack, Mass	5,150
Mechanicsville	No name listed	Hudson, New York	6,300
Jackson Bluff	Florida Power Corp	Oklicknee, Florida	8,800
Ozark	Empire Dist Elec Co.	Finley Creek, Mo.	7,200
Lower Dam	Twin City Rapid Tran.	Mississippi, Minn.	8,000
Nolickucky	No name listed	Nolickucky, Tenn.	10,640
Grace	Utah Power & Light	Bear, Utah	11,000
Lewistone	Wash Power & Light	Clearwater, Idaho	10,000
American River	Pacific Gas & Elec.	S Fk. American, Calif.	5,477

These are but a few of the many sites which could serve as demonstration projects for small-scale hydropower development. Additional study is needed to establish demonstration site criteria, select at least 50 sites with demonstration potential, and determine whether these sites would be available for demonstration purposes. The Corps of Engineers recommends the authorization and funding of such a study.

In addition to the demonstration program, a research program to develop small-scale hydropower planning, design, construction, and implementation techniques is needed. The suggested scope of such a program involves relatively low-intensity efforts addressed to as many different issues as possible in order to further define the magnitude and severity of the issues discussed in Chapter 2 and summarized below. Furthermore, the studies should be designed to provide results which can be adopted and used by local consulting firms, city engineering departments, and individual owners of small dams.

Review of Constraints and Suggested Approaches

Engineering Feasibility Factors

Issue 1: There is a need to further develop and refine small-scale hydropower turbine technology.

- Direct federal research and development funds to the basic study of low-head turbine design and small-scale package plants which can be tested in a selected number of demonstration projects.

- Direct federal R&D funds to the development of nonturbine based low-head hydropower technology.

Issue 2: There is a need to develop simplified hydrology, reservoir yield, and power plant capacity analysis techniques.

- Develop simplified hydrologic analysis and hydropower engineering techniques for use in designing small-scale hydropower facilities. Existing techniques need to be simplified because the economics of small-scale hydropower development will not support extensive and expensive engineering investigations at each potential site.

Issue 3: Many potential hydropower dams require major rehabilitation.

- Determine the likely extent and cost of the rehabilitation required for full scale implementation of a small-scale hydropower development program. The Corps of Engineers has recommended to the Congress that further funds be appropriated for the dam safety inspection program to identify and correct high hazard conditions which may result in loss of life or property. Such an inspection program could also provide some of the necessary data to determine the amount and cost of rehabilitation which would be required to retrofit any potential site with a hydropower plant. The relative deterioration of a dam should be included as a criterion for selection of demonstration projects so various rehabilitation techniques can be tested and cost comparisons can be performed.

Issue 4: The design of power transmission grids and switching systems becomes extremely complex when small-scale hydropower units are included in the network.

- Perform a state-of-the-art study to determine the most effective way to interface small-scale hydropower plants with existing and planned regional grids. A task force composed of representatives from federal agencies, utility consulting firms, and public or private utilities should be formed to define and direct research in this area.

Issue 5: The relative economic efficiency and financial feasibility of small-scale hydropower versus alternative electrical generation techniques is unknown.

- Develop data to determine the costs of retrofitting existing dams for hydropower production--especially for small dams.

- Conduct a short-term study of the relative economic efficiency of alternative electrical generation systems. In addition to the usual study of required capital outlays, annual variable costs, and expected annual average yield in kilowatt-hours and revenues, such a study should include:

  (a) the effects of present-price costing versus life-cycle costing on economic efficiency.

  (b) a net energy analysis of competitive systems. This technique attempts to measure the total energy required to construct equipment, produce fuels and operate and maintain physical plant versus the energy produced by each kind of facility.

Issue 6: Diverting reservoir storage from current use to hydropower production could be inefficient and cause significant economic stress in many instances.

- Review applicable value of water concepts developed by the National Water Commission and by a number of water resource institutions. These concepts could be combined with electricity values determined by present and forecasted market conditions to give a better understanding of the economic shifts, if any, which may occur from the development of small-scale hydropower.

Issue 7: The ecologic impacts of peak load power production by small-scale hydropower plants are possibly significant:

- Collect data on existing small-scale hydropower facilities to determine the character and magnitude of upstream and downstream ecologic impacts.

- Develop clearly defined standards for environmental review of proposed small-scale hydropower facilities.

- Direct federal efforts toward regional and basin-level studies of the possible environmental implications of small-scale hydropower development. Such studies would provide a framework for analysis of individual sites by state, local, and private interests.

Social Considerations

Issue 8: The social effects of a small-scale hydropower program are numerous, diffuse, and largely unknown.

- Conduct a full-scale technology assessment for the small-scale hydropower development program to identify potentially desirable and undesirable social effects at the individual, the community, and the national levels.

Issue 9: Institutional barriers may retard or prevent development of small-scale hydropower.

- An interagency task force should be organized to:

(a) Conduct a study to identify and define institutional barriers due to existing federal law, regulatory processes, or agency policies.

(b) Direct similar studies of state, local, and private sector barriers by funding studies of five states with significant small-scale hydropower potential.

APPENDIX A

HYDROPOWER ESTIMATION PROCEDURE FOR SMALL DAMS

The Corps' estimate of hydropower potential at existing dams with less than 5,000 KW capacity was performed using a methodology developed by the Corps' Institute for Water Resources. The methodology relies on existing data sources and, particularly, on the collective judgment and experience of Corps planners and engineers in each field office to derive power potential statistics for river basins within each District's boundaries. The derived estimate of potential is based on the rationale that:

(1) with general knowledge of streamflow amounts and variations; and

(2) with knowledge of the number and engineering characteristics of existing dams in a basin; and

(3) with the assumption that existing dams were designed rationally; an experienced engineer who is familiar with a local area can allocate dams throughout a basin such that an assumed distribution of dams on the average will approximate the actual distribution of existing dams. Then, the total hydropower potential of a basin based on an assumed distribution of dams will give a good approximation of the potential of the sum of the actual individual sites.

Three parameters are needed to calculate the power generated at a hydroelectric project: (1) hydraulic head on the turbine; (2) the amount of water flowing through the turbine; and (3) the efficiency of the turbine/generator system. These parameters are entered into the hydropower formula:

$$P = \frac{Qhe}{11.8}$$

where
P = power production in kilowatts
Q = flow through turbine in cubic feet per second
h = hydraulic head on the turbine in feet
e = efficiency
11.8 = a constant that accounts for the weight of the water, (62.5 lbs/ft^3) and the rate that work is performed (1 kilowatt = 737 ft-lb/sec)

The hydraulic head (h) is the difference in height between the water levels upstream and downstream of a dam minus the losses due to friction and other causes as the water passes through the project.[1] Both the upstream and downstream water levels will vary depending on the amount of water flowing into a reservoir and the amount of water discharged through the turbine during any given time interval. For this study, the maximum height of the dam, a characteristic measured during the Dam Safety Inventory, was used to estimate maximum potential hydraulic head.

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[1] Hydraulic head is readily convertible to pressure (100 ft. of head x 62.5 $\text{lbs/ft.}^3 \div 144\ \text{in}^2/\text{ft.}^2 = 43.4$ psi).

The determination of Q, the flow of water through the turbine, normally requires a detailed hydrologic investigation using nearby river gauges which record yearly streamflow variation. Reliable Q (often associated with the firm capacity of a hydropower plant) depends on the relationship between streamflow and the amount of reservoir storage available to smooth out periods of high and low river flows. On a highly developed river such as the Columbia or the Mississippi, Q depends not only on the reservoir storage of a particular site, but also on the regulation and operation of a number of upstream dams as well.

The final element in the power equation is the efficiency (e). The efficiency of modern turbines and generators operating at design capacity is relatively high--on the order of 80-90 percent. For this study, a uniform efficiency of 0.9 was used for all hydropower calculations.

Streamflow characteristics at most of the 49,500 dams in the Corps' listing are not known and could not be determined in time to meet the 90-day deadline for this study. Instead, a method was derived which assessed average river flows for different types of streams in each river basin in the United States. Then the existing dams in each basin, grouped into low, medium, and high head and storage categories (see Table A-1) were allocated to the various river reaches in each basin by Corps field engineers and the maximum power potential of each category was computed. Finally, a set of correction factors derived by IWR were incorporated to estimate the expected capacity and electrical generation for each category of dams. The detailed procedure which was used to estimate hydropower potential is as follows:

(1) Each river basin was partitioned into four streamflow zones:

- (a) intermittent = zero flow one to six months every year
- (b) frequent zero = zero flow one week every year
- (c) low-base flow = 0 - 50 percent of average discharge at the mouth of the basin
- (d) high-base flow = 50 - 100 percent of average discharge at the mouth of the basin.

If there were extreme variations in river basin terrain, the streamflow zones were further subdivided into topographic zones. Then the drainage area of each streamflow (or streamflow-topographic) zone was estimated and the average drainage area for each type of stream in each zone was calculated.

(2) Generalized streamflow versus drainage area relationships were extracted from a U.S. Geological Survey study.[2] These relationships were used to estimate average annual Q in each streamflow (or streamflow/topographic) zone.

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[2] U.S. Geological Survey, "A National Study of the Streamflow Data - Collection Program," 1971, 50 reports (one for each state).

(3) A Corps data file containing a listing of all existing dams and their engineering characteristics was sorted by river basin into 16 hydraulic head-reservoir storage categories.

Table A-1

Prototype Dam Characteristics

Hydraulic Head	Reservoir Storage
Low head (6-20 ft)	Low storage (15-100 acre-ft)
Moderate head (20-50 ft)	Moderate storage (100-1,000 acre-ft)
High head (50-100 ft)	High storage (1,000-10,000 acre-ft)
Head greater than 100 ft	Storage greater than 10,000 acre-ft

The number of dams in each category was counted and the average maximum head and maximum storage of the dams in each category was calculated. The Corps analysis of small-scale hydropower potential was limited to the nine categories with head less than 100 ft or storage less than 10,000 acre-ft.

(4) Each category of dams (called prototype dams) was allocated to one or more streamflow (or streamflow-topographic) zones based on the size of the drainage area, the quantity of streamflow, the configuration of the river basin and its valleys, and the prototype's average head and storage characteristics. It was assumed that all of the individual existing small dams in a basin were rationally sited and were designed to conform to site conditions. The resulting distribution of prototype dams, on the average, approximates the distribution of existing dams and collectively exhibits similar hydropower production potential.

(5) The hydropower potential of each prototype dam was calculated. Flow through the turbine is computed as average streamflow plus the release of all reservoir storage during one week; hydraulic head is set equal to maximum height of dam; and efficiency is assumed to be 0.9. The resulting maximum power potential for each prototype is multiplied by the number of dams in this category and then summed across prototypes to give the maximum power potential for each basin.

(6) Power potential is converted to an estimate of actual energy potential by multiplying by a factor, called the continuous power factor, which is a measure of the dependability of river flows and the regulation ability of a reservoir. Dams on intermittent streams with small reservoir storage will produce power for only short periods of time each year and have small continuous power factors. The opposite is true of high storage

dams on continuous discharge streams. Example continuous power factors used in the analysis are listed below:

Table A-2

Continuous Flow Factors

Streamflow Zone	Prototype Characteristic	Continuous Power Factor
Intermittent	Low Storage	.10
Frequent Zero Flow	Low Storage	.20
	Moderate Storage	.30
Low Base Flow	Low Storage	.20
	Moderate Storage	.30
	High Storage	.50
High Base Flow	Low Storage	.40
	Moderate Storage	.60
	High Storage	.80

(7) Finally, the installed or nameplate capacity of each prototype dam is determined by multiplying the energy potential by a plant factor. The plant factor is also dependent on the ability of a reservoir to regulate streamflows. For small storage dams, streamflow must almost immediately be passed through a turbine to avoid overtopping of the dam. Thus, the dam would be operated as a "run-of-the-river" power producer, and the turbine design would be closely matched to average daily streamflow (plant factor = 1.0). On the other hand, a large storage dam would likely be operated to produce high value peak load power. Thus, daily average flows would be passed through the turbine during a 3- or 4-hour period and the turbine should be significantly larger. Example plant factors used for this analysis are listed in Table A-3.

(8) To compute electricity produced during one year in kilowatt-hours, energy potential is multiplied by 8,760 hours. Since the energy potential already includes an adjustment for the proportion of time the dam would be producing energy, the result is electricity yield during a typical year.

Table A-3

Plant Factors

Streamflow Zone	Prototype Dam Characteristic	Plant Factor
Intermittent	Low Storage	1.0
Frequent Zero	Low Storage	1.0
	Moderate Storage	1.67
Low Base Flow	Low Storage	1.1
	Moderate Storage	2.0
	High Storage	10.0
High Base Flow	Low Storage	1.11
	Moderate Storage	1.67
	High Storage	4.0

APPENDIX B

REGIONAL STATISTICS

Statistics on the maximum hydropower potential at existing dams for each river basin in each major river region of the U.S. are presented in this appendix. It should be recognized that there is a larger potential for error in the estimates for each basin than for the nation or each region, since the estimation methodology relies on the tendency for high and low basin estimates to cancel out. Each regional summary also includes tabulations of several of the engineering characteristics of the dams in each region.

REGIONAL HYDROPOWER AND HYDROPOWER POTENTIAL STATISTICS

NEW ENGLAND: MAJOR DRAINAGE

	Existing Hydropower Production Facilities		Large Dam Potential (Greater than 5,000 KW Capacity)						Small Dam Potential (Less than 5,000 KW)		Total Basin Potential	
			Rehabilitation Potential (9%)		Hydro Expansion Potential		Hydro Installation Potential					
Basin Name	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)
St. John-St. Croix	29.9	114.9	2.7	10.3	0.2	1.0	0	0	10.2	56	12.1	67.3
Penobscot	152.6	838.8	13.7	75.5	3.6	23.7	0	0	93.7	608	111.1	707.2
Kennebac-Androscoggin	355.8	1,809.6	32.0	162.9	26.7	98.7	34.0	116.0	341.0	2,129	433.1	2,506.6
Saco	46.4	266.3	4.2	24.0	25.6	104.5	0	0	83.9	410	113.6	538.5
Merrimack	67.8	270.1	6.1	24.3	50.2	95.0	72.0	141.9	436.8	1,985	565.1	2,246.2
Mass.-R.I. Coastal	1.6	4.3	0.1	0.4	0	0	0	0	244.6	1,058	244.8	1,058.4
Long Island Sound	111.7	321.9	10.0	29.0	0	0	13.0	40.0	314.8	1,393	337.8	1,462.0
Connecticut	655.9	2,092.9	59.0	188.3	81.2	179.0	104.5	219.0	905.5	4,038	1,150.2	4,624.3
St. Francis	0	0	0	0	0	0	0	0	1.8	8	1.8	8.0
	1,426.7	5,718.8	127.3	514.7	187.5	501.9	223.5	516.9	2,432.3	11,685	2,970.0	13,218.5

NUMBER OF DAMS SORTED BY HEIGHT AND STORAGE CHARACTERISTICS

Maximum Height (Feet)	Maximum Storage (Acre-Feet)			
	0-99	100-999	1,000-9,999	More than 10,000
0-19	850	860	231	59
20-49	193	324	181	21
50-99	17	28	43	15
More than 100	6	4	10	24

NUMBER OF DAMS SORTED BY TYPE AND AGE

Type of Dam	Year Dam Completed			
	Before 1931	1931-1955	1956 to date	Unknown
Earth	1,021	157	233	0
Rockfill	195	27	8	0
Gravity	630	217	123	0
Buttress	109	7	7	0
Arch	6	1	0	0
Multi-Arch	0	0	0	0
Other	114	10	1	0

REGIONAL HYDROPOWER AND HYDROPOWER POTENTIAL STATISTICS

MID-ATLANTIC: MAJOR DRAINAGE

	Existing Hydropower Production Facilities		Large Dam Potential (Greater than 5,000 KW Capacity)						Small Dam Potential (Less than 5,000 KW)		Total Basin Potential	
			Rehabilitation Potential (9%)		Hydro Expansion Potential		Hydro Installation Potential					
Basin Name	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)
Richelieu	0	0	0	0	0	0	0	0	1,211.5	3,730	1,211.5	3,730.0
Upper Hudson	379.7	1,670.8	34.2	150.4	187.0	267.7	6.4	20.0	1,883.4	5,628	3,660.6	9,675.1
Lower Hudson									1,549.6	3,609		
Delaware	69.3	157.8	6.2	13.3	40.0	77.6	170.6	392.0	152.0	245	368.8	727.9
Susquehanna	827.9	3,307.4	74.5	297.7	338.0	1,600.0	246.3	203.0	413.4	721	1,072.2	2,821.7
Upper Chesapeake Bay	13.4	65.1	1.2	5.9	0	0	97.5	177.0	5.6	25	217.9	637.9
Potomac									113.6	430		
Lower Chesapeake Bay	30.4	112.8	2.7	10.2	0	0	0	0	250.6	891	253.3	901.2
	1,320.7	5,313.9	118.8	477.5	565.0	1,945.3	520.8	792.0	5,580.0	15,279	6,784.4	18,493.8

NUMBER OF DAMS SORTED BY HEIGHT AND STORAGE CHARACTERISTICS

Maximum Height (Feet)	Maximum Storage (Acre-Feet)			
	0-99	100-999	1,000-9,999	More than 10,000
0-19	608	741	143	26
20-49	439	459	168	30
50-99	71	95	76	46
More than 100	11	3	17	37

NUMBER OF DAMS SORTED BY TYPE AND AGE

Type of Dam	Year Dam Completed			
	Before 1931	1931-1955	1956 to date	Unknown
Earth	713	490	981	0
Rockfill	34	8	19	0
Gravity	346	106	72	0
Buttress	15	6	4	0
Arch	7	6	3	0
Multi-Arch	2	0	0	0
Other	110	24	27	0

REGIONAL HYDROPOWER AND HYDROPOWER POTENTIAL STATISTICS

SOUTH ATLANTIC GULF: MAJOR DRAINAGE

	Existing Hydropower Production Facilities		Large Dam Potential (Greater than 5,000 KW Capacity)						Small Dam Potential (Less than 5,000 KW)		Total Basin Potential	
			Rehabilitation Potential (9%)		Hydro Expansion Potential		Hydro Installation Potential					
Basin Name	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)
Roanoke	855.3	1,286.6	77.0	115.8	855.3	1,286.6	0	0	17.6	26	949.9	1,428.4
Tar-Neuse	1.6	5.7	0.1	0.5	1.6	5.7	0	0	19.4	34	21.1	40.2
Cape Fear	0.8	2.1	0.1	0.2	0.8	2.1	10.0	21.9	83.0	103	93.9	127.2
Pee Dee	311.3	1,262.0	28.0	113.6	0	0	0	0	384.4	1,542	412.4	1,655.6
Santee-Edisto	1,255.8	2,649.4	113.0	238.4	47.4	667.7	0	0	618.7	1,716	779.1	2,622.1
Savannah-Ogeechee	894.1	1,901.4	80.5	171.1	66.0	100.0	0	0	1,188.9	10,415	1,335.4	10,686.1
Altamaha-St. Marks	63.4	247.8	5.7	22.3	0	0	19.0	99.0	455.4	3,989	480.1	4,110.3
St. Johns	0	0	0	0	0	0	0	0	1.0	12	1.0	12.0
Southern Florida	0	0	0	0	0	0	0	0	0	0	0	0
Tampa Bay	0	0	0	0	0	0	0	0	3.3	44	3.3	44.0
Suwannee	0	0	0	0	0	0	0	0	5.1	26	5.1	26.0
Ochlockonee	0	0	0	0	0	0	0	0	0	0	0	0
Appalachicola	545.2	2,067.4	49.1	186.1	545.2	2,067.4	267.2	334.4	202.9	1,099	1,064.4	3,686.9
St. Josephs-Perdido	7.6	23.8	0.7	2.1	7.6	23.8	0	0	213.0	489	221.3	514.9
Alabama	1,575.2	4,539.8	141.8	408.6	1,575.2	4,539.8	527.1	547.0	745.8	1,282	2,989.9	6,777.4
Tombigbee	242.6	535.0	21.8	48.2	242.6	535.0	51.0	253	165.2	735	480.6	1,571.2
Pascagoula	0	0	0	0	0	0	0	0	47.6	143	47.6	143.0
Pearl	0	0	0	0	0	0	0	0	93.0	190	93.0	190.0
	5,752.9	14,521.0	517.8	1,306.9	3,341.7	9,228.1	874.3	1,255.3	4,244.3	21,845	8,978.1	33,635.3

B-4 (Cont'd)

NUMBER OF DAMS SORTED BY HEIGHT AND STORAGE CHARACTERISTICS

Maximum Height (Feet)	Maximum Storage (Acre-Feet)			
	0-99	100-999	1,000-9,999	More than 10,000
0-19	2,963	1,547	98	67
20-49	661	1,111	201	74
50-99	14	51	40	59
More than 100	1	0	3	36

NUMBER OF DAMS SORTED BY TYPE AND AGE

Type of Dam	Year Dam Completed			
	Before 1931	1931-1955	1956 to date	Unknown
Earth	436	1,822	4,257	0
Rockfill	7	3	9	0
Gravity	88	23	27	0
Buttress	14	5	1	0
Arch	23	8	4	0
Multi-Arch	2	0	0	0
Other	49	52	96	0

REGIONAL HYDROPOWER AND HYDROPOWER POTENTIAL STATISTICS

GREAT LAKES: MAJOR DRAINAGE

	Existing Hydropower Production Facilities		Large Dam Potential (Greater than 5,000 KW Capacity)						Small Dam Potential (Less than 5,000 KW)		Total Basin Potential	
			Rehabilitation Potential (9%)		Hydro Expansion Potential		Hydro Installation Potential					
Basin Name	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)
Western Lake Superior	128.2	625.9	11.5	56.3	0	0	0	0	185.2	579	292.0	777
Southern Lake Superior									95.3	142		
Northwest Lake Michigan	298.3	1,216.4	26.8	109.5	9.5	41.0	0	0	61.4	1,154	256.4	1,532
Southwest Lake Michigan									74.6	82		
Southeast Lake Michigan									44.4	77		
Northeast Lake Michigan									39.7	68		
Northwest Lake Huron	120.6	659.7	10.9	59.4	2,0	7.0	0	0	44.4	56	73.2	192
Southwest Lake Huron									12.0	50		
St. Clair-Detroit									3.9	20		
Western Lake Erie	2.6	11.3	0.2	1.0	0	0	0	0	69.8	108	75.3	135
Southern Lake Erie									4.0	20		
Eastern Lake Erie									1.3	6		
Southwest Lake Ontario	3,458.5	22,241.0	311.3	2,001.7	241.2	530.2	142.6	580.5	0	0	702.8	3,173
Southeast Lake Ontario									0	0		
Northeast Lake Ontario–St. Lawrence									7.7	61		
	4,008.2	24,754.3	360.7	2,227.9	252.7	578.2	142.6	580.5	643.7	2,423	1,400	5,809

NUMBER OF DAMS SORTED BY HEIGHT AND STORAGE CHARACTERISTICS

Maximum Height (Feet)	Maximum Storage (Acre-Feet)			
	0-99	100-999	1,000-9,999	More than 10,000
0-19	362	368	106	37
20-49	86	125	93	36
50-99	2	3	11	12
More than 100	0	1	1	1

NUMBER OF DAMS SORTED BY TYPE AND AGE

Type of Dam	Year Dam Completed			
	Before 1931	1931-1955	1956 to date	Unknown
Earth	325	220	330	0
Rockfill	6	0	1	0
Gravity	239	78	31	0
Buttress	3	0	0	0
Arch	0	2	0	0
Multi-Arch	1	3	0	0
Other	1	2	2	0

REGIONAL HYDROPOWER AND HYDROPOWER POTENTIAL STATISTICS

OHIO RIVER: MAJOR DRAINAGE

	Existing Hydropower Production Facilities		Large Dam Potential (Greater than 5,000 KW Capacity)						Small Dam Potential (Less than 5,000 KW)		Total Basin Potential	
			Rehabilitation Potential (9%)		Hydro Expansion Potential		Hydro Installation Potential					
Basin Nsme	Capacity (MW)	Output (10^{6}KWH)	Capacity (MW)	Output (10^{6}KWH)	Capacity (MW)	Output (10^{6}KWH)	Capacity (MW)	Output (10^{6}KWH)	Capacity (MW)	Output (10^{6}KWH)	Capacity (MW)	Output (10^{6}KWH)
Allegheny	54.9	97.9	4.9	8.8	0	0	0	0	57.6	61	62.5	69.8
Monongahela	70.4	152.8	6.3	13.8	0	0	465	173	63.5	74	534.8	260.8
Pittsburgh-Wheeling-Beaver	0.1	0.5	-	-	0	0	0	0	172.9	173	172.9	173
Muskingum	259.6	1,126.3	23.4	101.4	0	0	270	877	233.1	260	1,546.0	2,239.4
Kanawha									314.7	315		
Scioto									77.1	90		
Portsm.-L.Kanswha-B.Sandy									627.7	596		
Great Miami	2.5	9.3	0.2	0.8	0	0	0	0	22.6	55	37.0	108.8
Cinc-Little Miami									14.2	53		
Licking-Kentucky	30.3	75.2	2.7	6.8	0	0	9.4	53	28.7	90	40.8	150
Louisville-Salt			0	0	0	0	0	0	7.1	27	7.1	27
White-Patoka	17.7	60.0	1.6	5.4	0	0	0	0	54.2	146	90.3	274.4
Wabash									34.5	123		
Cumberland	884.9	3,095.0	79.6	278.6	0	0	0	0	101.3	625	180.9	903
Evansville-Green			0	0	0	0	0	0	64.3	161	64.3	161
Ohio Main Stream	145.1	888.0	13.6	79.9	19.2	100	670.1	3,577			702.9	3,757
	1,465.5	5,505	132.3	495.5	19.2	100	1,414.5	4,680	1,873.5	2,849	3,439.5	8,124

NUMBER OF DAMS SORTED BY HEIGHT AND STORAGE CHARACTERISTICS

Maximum Height (Feet)	Maximum Storage (Acre-Feet)			
	0-99	100-999	1,000-9,999	More than 10,000
0-19	301	150	25	5
20-49	1,056	697	138	33
50-99	82	117	91	43
More than 100	30	34	13	46

NUMBER OF DAMS SORTED BY TYPE AND AGE

Type of Dam	Year Dam Completed			
	Before 1931	1931-1955	1956 to date	Unknown
Earth	190	778	1,559	0
Rockfill	8	5	31	0
Grsvity	54	46	28	0
Buttress	0	1	0	0
Arch	1	0	0	0
Multi-Arch	1	0	0	0
Other	37	31	93	0

REGIONAL HYDROPOWER AND HYDROPOWER POTENTIAL STATISTICS

TENNESSEE RIVER: MAJOR DRAINAGE

	Existing Hydropower Production Facilities		Large Dam Potential (Greater than 5,000 KW Capacity)						Small Dam Potential (Less than 5,000 KW)		Total Basin Potential	
			Rehabilitation Potential (9%)		Hydro Expansion Potential		Hydro Installation Potential					
Basin Name	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)
Upper Tennessee	3,658.4	16,111.5	329.3	1,450	30.1	139	0	0	35.1	185	434.3	1,960
Tenn-Hiwassee-Sequatchie									8.2	47		
Tenn-Elk									23.8	105		
Lower Tennessee									7.8	34		
	3,658.4	16,111.5	329.3	1,450	30.1	139	0	0	74.9	371	434.3	1,960

NUMBER OF DAMS SORTED BY HEIGHT AND STORAGE CHARACTERISTICS

Maximum Height (Feet)	Maximum Storage (Acre-Feet)			
	0-99	100-999	1,000-9,999	More than 10,000
0-19	111	55	2	0
20-49	79	105	25	0
50-99	7	13	15	10
More than 100	0	4	3	30

NUMBER OF DAMS SORTED BY TYPE AND AGE

Type of Dam	Year Dam Completed			
	Before 1931	1931-1955	1956 to date	Unknown
Earth	14	85	265	2
Rockfill	2	11	5	0
Gravity	15	24	10	0
Buttress	3	2	0	0
Arch	9	4	0	0
Multi-Arch	1	0	0	0
Other	3	2	2	0

REGIONAL HYDROPOWER AND HYDROPOWER POTENTIAL STATISTICS

UPPER MISSISSIPPI: MAJOR DRAINAGE

	Existing Hydropower Production Facilities		Large Dam Potential (Greater than 5,000 KW Capacity)						Small Dam Potential (Less than 5,000 KW)		Total Basin Potential	
			Rehabilitation Potential (9%)		Hydro Expansion Potential		Hydro Installation Potential					
Basin Name	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)
Minnesota	1.0	2.9	0.1	0.3	0	0	0	0	83.4	82	83.5	82.3
Mississippi Headwaters	4.6	22.5	0.4	2.0	0	0	0	0	2,884.1	5,183	2,884.5	5,185.0
St. Croix	31.6	150.9	2.8	13.6	0	0	0	0	44.9	196	47.7	209.6
Chippewa	161.5	672.5	14.5	60.5	58.9	150.0	0	0	57.0	131	130.4	341.5
Mississippi-Black-Root	7.0	24.7	0.6	2.2	2.2	4.0	0	0	23.9	108	26.7	114.2
Wisconsin	148.3	770.7	13.4	69.4	2.8	5.6	0	0	593.9	714	610.1	789.0
Miss-Maquoketa-Plum	1.2	5.0	0.1	0.4					0.9	4	1.0	4.4
Rock	5.2	26.0	0.5	2.3	0	0	6.8	37.0	31.9	124	39.2	163.3
Des Moines	3.0	11.0	0.3	1.0	0	0	17.2	103.6	31.7	148	49.2	252.6
Miss-Iowa-Quad	1.5	3.6	0.1	0.3	0	0	0	0	514.5	1,824	514.6	1,824.3
Miss-Salt-Quincy	0	0	0	0	0	0	0	0	6.5	36	6.5	36.0
Upper and Lower Illinois	22.4	93.8	2.0	8.4	0	0	69.6	368.0	66.6	230	138.2	606.4
Miss-Kaskaskin-St Louis	0	0	0	0	0	0	0	0	39.1	211	39.1	211.0
Mississippi Main Stream	194.0	1,222.7	17.5	110.0	16.0	100.9	105.1	568.6			138.6	779.5
	581.3	3,006.3	52.3	270.4	79.9	260.5	198.7	1,077.2	4,378.4	8,991	4,709.3	10,599.1

NUMBER OF DAMS SORTED BY HEIGHT AND STORAGE CHARACTERISTICS

Maximum Height (Feet)	Maximum Storage (Acre-Feet)			
	0-99	100-999	1,000-9,999	More than 10,000
0-19	476	387	190	91
20-49	1,256	584	117	53
50-99	15	68	59	29
More than 100	0	2	4	1

NUMBER OF DAMS SORTED BY TYPE AND AGE

Type of Dam	Year Dam Completed			
	Before 1931	1931-1955	1956 to date	Unknown
Earth	146	388	2,071	0
Rockfill	4	5	12	0
Gravity	249	323	85	0
Buttress	2	3	1	0
Arch	2	1	0	0
Multi-Arch	1	0	0	0
Other	5	19	14	0

B-8 (Cont'd)

REGIONAL HYDROPOWER AND HYDROPOWER POTENTIAL STATISTICS

LOWER MISSISSIPPI: MAJOR DRAINAGE

	Existing Hydropower Production Facilities		Large Dam Potential (Greater than 5,000 KW Capacity)						Small Dam Potential (Less than 5,000 KW)		Total Basin Potential	
			Rehabilitation Potential (9%)		Hydro Expansion Potential		Hydro Installation Potential					
Basin Name	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)
Miss-Hatchee	0	0	0	0	0	0	18.0	83.0	514.9	2,001	532.9	2,084
Miss-St. Francis	0	0	0	0	0	0	7.5	21.0	1,999.7	5,518	2,007.2	5,539
Miss-Yazoo	0	0	0	0	0	0	0	0	21.6	186	21.6	186
Quachita	205.8	423.5	18.5	38.1	87.7	135.6	0	0	6.4	53	112.6	227
Miss-Tensas	0	0	0	0	0	0	0	0	1.5	2	1.5	2
Miss-Big Black	0	0	0	0	0	0	0	0	12.3	108	12.3	108
Miss-Lake Maurepas	0	0	0	0	0	0	0	0	24.0	232	24.0	232
Lousisna Coastal	0	0	0	0	0	0	0	0	1.0	8	1.0	8
Miss Delta	0	0	0	0	0	0	0	0	0.2	2	0.2	2
	205.8	423.5	18.5	38.1	87.7	135.6	25.5	104.0	2,581.6	8,110	2,713.3	8,388

NUMBER OF DAMS SORTED BY HEIGHT AND STORAGE CHARACTERISTICS

Maximum Height (Feet)	Maximum Storage (Acre-Feet)			
	0-99	100-999	1,000-9,999	More than 10,000
0-19	1,131	585	80	6
20-49	371	293	45	23
50-99	3	3	9	10
More than 100	0	0	0	6

NUMBER OF DAMS SORTED BY TYPE AND AGE

Type of Dam	Year Dam Completed			
	Before 1931	1931-1955	1956 to date	Unknown
Earth	38	691	1,790	0
Rockfill	2	8	9	0
Gravity	4	3	9	0
Buttress	0	0	1	0
Arch	1	0	0	0
Multi-Arch	0	0	0	0
Other	2	4	1	0

REGIONAL HYDROPOWER AND HYDROPOWER POTENTIAL STATISTICS

HUDSON BAY: MAJOR DRAINAGE

	Existing Hydropower Production Facilities		Large Dam Potential (Greater than 5,000 KW Capacity)						Small Dam Potential (Less than 5,000 KW)		Total Basin Potential	
			Rehabilitation Potential (9%)		Hydro Expansion Potential		Hydro Installation Potential					
Basin Name	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)
Souris	4.0	21.3	0.4	1.9	0	0	0	0	0.2	0	48.4	67
Red									47.8	65		
Rainy	9.6	46.7	0.9	4.2	0	0	0	0	3.1	7	4.0	11
	13.6	68.0	1.3	6.1	0	0	0	0	51.1	72	52.4	78

NUMBER OF DAMS SORTED BY HEIGHT AND STORAGE CHARACTERISTICS

Maximum Height (Feet)	Maximum Storage (Acre-Feet)			
	0-99	100-999	1,000-9,999	More than 10,000
0-19	40	90	49	43
20-49	19	31	16	3
50-99	5	5	3	0
More than 100	0	0	0	0

NUMBER OF DAMS SORTED BY TYPE AND AGE

Type of Dam	Year Dam Completed			
	Before 1931	1931-1955	1956 to date	Unknown
Earth	0	97	96	0
Rockfill	0	1	0	0
Gravity	22	55	4	0
Buttress	0	2	0	0
Arch	0	0	0	0
Multi-Arch	0	0	0	0
Other	2	16	9	0

REGIONAL HYDROPOWER AND HYDROPOWER POTENTIAL STATISTICS

MISSOURI: MAJOR DRAINAGE

	Existing Hydropower Production Facilities		Large Dam Potential (Greater than 5,000 KW Capacity)						Small Dam Potential (Less than 5,000 KW)		Total Basin Potential	
			Rehabilitation Potential (9%)		Hydro Expansion Potential		Hydro Installation Potential					
Basin Name	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)
St. Mary	0	0	0	0	0	0	0	0	0.	0	0	0
Missouri Headwaters	9.0	50.0	0.8	4.5	9.0	50.0	12.0	64.0	2.6	11	24.4	129.5
Missouri-Marias	463.8	3,070.0	41.7	276.3	377.0	1,425.7	11.0	41.0	14.9	47	458.6	1,821.0
Missouri-Musselshell									11.8	17		
Milk									1.9	12		
Missouri-Poplar									0.3	2		
Upper Yellowstone	286.6	1,226.6	25.8	110.4	0	0	279.3	491.0	3.8	5	335.6	651.4
Bighorn									19.5	28		
Tongue-Powder									2.9	13		
Lower Yellowstone									4.3	4		
Missouri-Little Missouri	0	0	0	0	0	0	0	0	6.5	9	6.5	9.0
Cheyenne	8.4	33.0	0.8	3.0	0	0	10.0	33.0	2.2	14	13.0	50.0
Missouri-Oahe	1,463.0	6,047.5	131.7	544.3	565.3	3,032.5	0	0	2.1	16	699.1	3,592.8
Missouri-White	320.2	1,680.1	28.8	151.2	0	0	0	0	9.3	22	38.1	173.2
Niobrara	103.9	710.2	9.3	63.9	2.6	11.0	0	0	0.2	2	12.1	76.9
James	0	0	0	0	0	0	0	0	1.5	10	1.5	10.0
Missouri-Big Sioux	0	0	0	0	0	0	0	0	8.1	8	8.1	8.0
North Platte	489.0	1,948.1	44.0	175.3	56.7	53.3	90.6	192.5	2.6	11	323.6	615.1
South Platte									114.9	157		
Loup									8.2	9		
Platte									3.7	2		
Elkhorn									2.9	15		

	Existing Hydropower Production Facilities		Large Dam Potential (Greater than 5,000 KW Capacity)						Small Dam Potential (Less than 5,000 KW)		Total Basin Potential	
			Rehabilitation Potential (9%)		Hydro Expansion Potential		Hydro Installation Potential					
Basin Name	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)
Missouri-Sioux City-Omaha	0	0	0	0	0	0	0	0	2.2	13	2.2	13
Missouri-Nemaha-Nodaway	0	0	0	0	0	0	0	0	1.8	16	1.8	16
Republican	3.9	16.3	0.3	1.5	0	0	83.0	285.0	6.8	8	93.5	320.5
Smoky Hill									1.4	9		
Kansas									2.0	77		
Grand-Charitan	0	0	0	0	0	0	0	0	3.9	34	3.9	34.0
Osage-Gasconade	221.8	511.7	20.0	46.1	26.5	59.7	0	0	4.6	40	51.1	145.8
Missouri-Kansas City	0	0	0	0	0	0	0	0	3.3	29	3.3	29.0
	3,369.6	15,293.5	303.2	1,376.5	1,037.1	4,632.2	485.9	1,106.5	250.2	580.	2,076.4	7,695.2

B-11 (Cont'd)

NUMBER OF DAMS SORTED BY HEIGHT AND STORAGE CHARACTERISTICS

Maximum Height (Feet)	Maximum Storage (Acre-Feet)			
	0-99	100-999	1,000-9,999	More than 10,000
0-19	2,941	864	69	12
20-49	5,562	1,838	252	50
50-99	61	81	105	54
More than 100	8	8	12	69

NUMBER OF DAMS SORTED BY TYPE AND AGE

Type of Dam	Year Dam Completed			
	Before 1931	1931-1955	1956 to date	Unknown
Earth	959	3,766	7,120	0
Rockfill	8	12	5	0
Gravity	25	23	10	0
Buttress	4	2	2	0
Arch	13	4	5	0
Multi-Arch	0	0	0	0
Other	11	8	10	0

REGIONAL HYDROPOWER AND HYDROPOWER POTENTIAL STATISTICS

ARKANSAS-WHITE-RED: MAJOR DRAINAGE

	Existing Hydropower Production Facilities		Large Dam Potential (Greater than 5,000 KW Capacity)						Small Dam Potential (Less than 5,000 KW)		Total Basin Potential	
			Rehabilitation Potential (9%)		Hydro Expansion Potential		Hydro Installation Potential					
Basin Name	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)
White	834.0	1,897.0	7. 1	170.7	109.0	171.8	28.0	47.0	362.7	1,091	574.8	1,480.5
Upper Arkansas	416.7	1,069.1	37.5	96.2	22.5	27.0	0	0	45.1	189	386.4	752.2
Arkansas in Kansas									15.0	47		
Upper Cimarron									10.8	21		
Lower Cimarron									30.7	46		
Arkansas Keystone									17.6	54		
Verdigris-Neosho									207.2	272		
Upper Canadian	518.0	1,806.3	46.6	162.6	0	0	217.5	274.8	1.5	10	1,250.6	3,151.4
Canadian in Texas									55.1	157		
Lower Canadian									55.7	139		
Lower Arkansas									874.2	2,408		
Red River Headwaters	70.0	247.0	6.3	22.2	105.0	70.0	0	0	19.5	171	392.4	1,028.2
Red-Washita									261.6	765		
Lower Red	0	0	0	0	0	0	0	0	360.9	1,155	360.9	1,155.0
	1,838.7	5,019.4	165.5	451.7	236.5	268.8	245.5	321.8	2,317.6	6,525	2,965.1	7,567.3

NUMBER OF DAMS SORTED BY HEIGHT AND STORAGE CHARACTERISTICS

Maximum Height (Feet)	Maximum Storage (Acre-Feet)			
	0-99	100-999	1,000-9,999	More than 10,000
0-19	1,270	385	35	7
20-49	1,514	1,386	150	33
50-99	28	106	83	70
More than 100	3	3	2	28

NUMBER OF DAMS SORTED BY TYPE AND AGE

Type of Dam	Year Dam Completed			
	Before 1931	1931-1955	1956 to date	Unknown
Earth	276	1,138	3,570	0
Rockfill	5	15	15	0
Gravity	15	23	23	0
Buttress	1	4	0	0
Arch	3	3	0	0
Multi-Arch	0	1	0	0
Other	2	8	2	0

REGIONAL HYDROPOWER AND HYDROPOWER POTENTIAL STATISTICS

TEXAS-GULF: MAJOR DRAINAGE

	Existing Hydropower Production Facilities		Large Dam Potential (Greater than 5,000 KW Capacity)						Small Dam Potential (Less than 5,000 KW)		Total Basin Potential	
			Rehabilitation Potential (9%)		Hydro Expansion Potential		Hydro Installation Potential					
Basin Name	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)
Sabine-Neches	133.0	331.1	12.0	29.8	0	0	2.9	22.5	41.4	130	56.3	183
Upper-Lower Trinity	0	0	0	0	0	0	0	0	69.3	199	69.3	199
Brazos	52.5	163.2	4.7	14.7	11.3	6.0	19.0	30.0	251.4	474	286.4	525
Colorado River of Texas	191.0	525.0	17.2	47.3	0	0	0	0	58.0	194	75.2	241
Guadalupe-San Antonio	16.3	54.7	1.5	4.9	0	0	20.8	8.4	30.5	58	52.1	71
Nueces-Frio	0	0	0	0	0	0	0	0	9.9	40	9.9	40
	392.8	1,074.0	35.4	96.7	11.3	6.0	42.7	60.9	460.5	1,095	549.2	1,259

NUMBER OF DAMS SORTED BY HEIGHT AND STORAGE CHARACTERISTICS

Maximum Height (Feet)	Maximum Storage (Acre-Feet)			
	0-99	100-999	1,000-9,999	More than 10,000
0-19	636	409	52	3
20-49	846	1,251	80	9
50-99	24	122	24	56
More than 100	0	0	0	24

NUMBER OF DAMS SORTED BY TYPE AND AGE

Type of Dam	Year Dam Completed			
	Before 1931	1931-1955	1956 to date	Unknown
Earth	166	582	2,689	0
Rockfill	5	1	1	0
Gravity	30	12	15	0
Buttress	15	5	9	0
Arch	0	0	0	0
Multi-Arch	0	0	0	0
Other	3	1	2	0

REGIONAL HYDROPOWER AND HYDROPOWER POTENTIAL STATISTICS

RIO GRANDE: MAJOR DRAINAGE

	Existing Hydropower Production Facilities		Large Dam Potential (Greater than 5,000 KW Capacity)						Small Dam Potential (Less than 5,000 KW)		Total Basin Potential	
			Rehabilitation Potential (9%)		Hydro Expansion Potential		Hydro Installation Potential					
Basin Name	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)
Rio Grande Headwaters	0	0	0	0	0	0	50.0	155.0	67.8	244	140.5	548.0
North Rio Grande									10.3	90		
Rio Grande Mimbres									6.7	26		
Rio Grande-Big Bend									5.7	33		
Rio Grande Closed	65.4	233.5	5.9	21.0	20.5	49.5	80.0	156.0	0.2	1	200.4	621.5
Upper Pecos									4.1	18		
Lower Pecos									9.2	33		
Rio Grande-Amistad									26.1	150		
Lower Rio Grande									54.4	193		
	65.4	233.5	5.9	21.0	20.5	49.5	130.0	311.0	184.5	788	340.9	1.169.5

NUMBER OF DAMS SORTED BY HEIGHT AND STORAGE CHARACTERISTICS

Maximum Height (Feet)	Maximum Storage (Acre-Feet)			
	0-99	100-999	1,000-9,999	More than 10,000
0-19	115	88	23	1
20-49	109	93	18	2
50-99	20	20	8	11
More than 100	3	1	4	10

NUMBER OF DAMS SORTED BY TYPE AND AGE

Type of Dam	Year Dam Completed			
	Before 1931	1931-1955	1956 to date	Unknown
Earth	66	135	299	0
Rockfill	1	1	2	0
Gravity	10	3	1	0
Buttress	1	0	0	0
Arch	4	0	0	0
Multi-Arch	0	0	0	0
Other	0	2	1	0

REGIONAL HYDROPOWER AND HYDROPOWER POTENTIAL STATISTICS

GREAT BASIN: MAJOR DRAINAGE

	Existing Hydropower Production Facilities		Large Dam Potential (Greater than 5,000 KW Capacity)						Small Dam Potential (Less than 5,000 KW)		Total Basin Potential	
			Rehabilitation Potential (9%)		Hydro Expansion Potential		Hydro Installation Potential					
Basin Name	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)
Bear	164.8	551.9	14.8	49.7	0	0	0	0	4.1	36	48.6	122.7
Great Salt Lake									29.7	37		
Sevier Lake	352.9	1,342.2	31.8	120.8	0	0	0	0	5.9	32	37.7	152.8
Humboldt	0	0	0	0	0	0	0	0	6.5	31	6.5	31.0
Central Lahontan	11.9	82.0	1.1	7.4	0.8	1.0	0	0	39.2	43	41.1	51.4
Tonopah Desert	0	0	0	0	0	0	0	0	0	0	0	0
	529.6	1,976.1	47.7	177.9	0.8	1.0	0	0	85.4	179	133.9	357.9

NUMBER OF DAMS SORTED BY HEIGHT AND STORAGE CHARACTERISTICS

Maximum Height (Feet)	Maximum Storage (Acre-Feet)			
	0-99	100-999	1,000-9,999	More than 10,000
0-19	60	85	16	1
20-49	34	105	47	16
50-99	3	14	27	13
More than 100	0	2	4	9

NUMBER OF DAMS SORTED BY TYPE AND AGE

Type of Dam	Year Dam Completed			
	Before 1931	1931-1955	1956 to date	Unknown
Earth	156	128	125	0
Rockfill	4	4	0	0
Gravity	11	1	0	0
Buttress	0	1	0	0
Arch	2	1	2	0
Multi-Arch	1	0	0	0
Other	0	0	0	0

REGIONAL HYDROPOWER AND HYDROPOWER POTENTIAL STATISTICS

UPPER COLORADO: MAJOR DRAINAGE

	Existing Hydropower Production Facilities		Large Dam Potential (Greater than 5,000 KW Capacity)						Small Dam Potential (Less than 5,000 KW)		Total Basin Potential	
			Rehabilitation Potential (9%)		Hydro Expansion Potential		Hydro Installation Potential					
Basin Name	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)
Upper Green	120.2	684.2	10.8	61.6	0.1	0.1	0	0	3.8	17	48.5	173.7
Yampa-White									11.9	54		
Lower Green									21.9	41		
Gunnison	181.8	722.2	16.4	65.0	15.5	80.0	0	0	6.0	32	37.9	177.0
Colorado Headwaters	41.5	171.6	3.7	15.4	0	0	0	0	300.2	304	303.9	319.4
Colorado-Delores	3.6	10.8	0.3	1.0	0	0	0	0	6.4	29	6.7	30.0
Upper San Juan	12.4	45.1	1.1	4.0	0	0	24	49	75.0	76	139.5	169.0
Colorado-San Juan									39.4	40		
	359.5	1,633.9	32.3	147.0	15.6	80.1	24	49	464.6	593	536.5	869.1

NUMBER OF DAMS SORTED BY HEIGHT AND STORAGE CHARACTERISTICS

Maximum Height (Feet)	Maximum Storage (Acre-Feet)			
	0-99	100-999	1,000-9,999	More than 10,000
0-19	189	179	26	4
20-49	168	256	62	7
50-99	8	27	35	13
More than 100	1	1	8	35

NUMBER OF DAMS SORTED BY TYPE AND AGE

Type of Dam	Year Dam Completed			
	Before 1931	1931-1955	1956 to date	Unknown
Earth	327	332	338	0
Rockfill	3	2	5	0
Gravity	3	1	0	0
Buttress	0	0	0	0
Arch	1	1	4	0
Multi-Arch	0	0	0	0
Other	0	2	0	0

REGIONAL HYDROPOWER AND HYDROPOWER POTENTIAL STATISTICS

LOWER COLORADO: MAJOR DRAINAGE

	Existing Hydropower Production Facilities		Large Dam Potential (Greater than 5,000 KW Capacity)						Small Dam Potential (Less than 5,000 KW)		Total Basin Potential	
			Rehabilitation Potential (9%)		Hydro Expansion Potential		Hydro Installation Potential					
Basin Name	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)
Little Colorado	2.9	7.3	0.3	0.7	0	0	0	0	87.3	526	402.8	1,394.3
Upper Gila Gila-San Pedro Gila-Salt	185.6	479.8	16.7	43.2	0	0	32.6	172				
Colorado-Lake Mead Colorado-Lake Mojave	2,658.4	10,053.6	239.3	535.4	0	0	26.6	117				
	2,846.9	10,540.7	256.3	579.3	0	0	59.2	289	87.3	526	402.8	1,394.3

NUMBER OF DAMS SORTED BY HEIGHT AND STORAGE CHARACTERISTICS

Maximum Height (Feet)	Maximum Storage (Acre-Feet)			
	0-99	100-999	1,000-9,999	More than 10,000
0-19	60	35	8	1
20-49	111	81	32	5
50-99	9	16	23	5
More than 100	24	2	6	14

NUMBER OF DAMS SORTED BY TYPE AND AGE

Type of Dam	Year Dam Completed			
	Before 1931	1931-1955	1956 to date	Unknown
Earth	47	132	197	0
Rockfill	5	1	6	0
Gravity	10	4	1	0
Buttress	0	1	0	0
Arch	3	12	3	0
Multi-Arch	5	1	0	0
Other	4	0	0	0

REGIONAL HYDROPOWER AND HYDROPOWER POTENTIAL STATISTICS

COLUMBIA-NORTH PACIFIC: MAJOR DRAINAGE

	Existing Hydropower Production Facilities		Large Dam Potential (Greater than 5,000 KW Capacity)						Small Dam Potential (Less than 5,000 KW)		Total Basin Potential	
			Rehabilitation Potential (9%)		Hydro Expansion Potential		Hydro Installation Potential					
Basin Name	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)
Kootenai	216.9	467.0	19.5	42.0	630.0	1,287.0	0	0	0.6	2	650.1	1,331.0
Pend Oreille	654.2	4,295.8	58.9	386.6	275.5	425.0	0.4	60.4	12.5	57	347.3	929.0
Spokane	146.4	1,012.0	13.2	91.1	50.0	158.0	0	0	42.3	42	105.5	291.1
Yakima	34.4	182.1	3.1	16.4	0	0	24.9	160.0	11.1	10	39.1	186.4
Upper Snake	3,586.4	19,029.3	322.8	1,712.6	538.0	477.5	187.2	869.0	6.1	28	1,186.0	3,528.1
Middle Snake									111.2	405		
Salmon									5.4	20		
Lower Snake									15.3	16		
Upper Columbia	15,187.1	91,381.6	1,366.8	8,224.3	8,456.8	11,536.0	114.7	501.0	25.9	30	10,164.9	20,795.3
Middle Columbia									45.6	170		
Lower Columbia									155.1	334		
Deschuttes	357.3	1,357.6	32.2	122.2	0	0	0	0	67.6	243	99.8	365.2
Willamette	696.3	2,847.6	62.7	256.3	0	0	128.5	556.0	102.3	448	293.5	1,260.3
Puget Sound	1,212.6	5,107.4	109.1	459.7	731.1	981.9	152.6	781.0	18.0	84	1,010.8	2,306.6
Washington Coastal	0	0	0	0	0	0	20.0	22.0	1.3	6	21.3	28.0
Oregon Coastal	250.8	1,501.9	22.6	135.2	0	0	0	0	122.3	536	144.9	671.2
Oregon Closed	0	0	0	0	0	0	0	0	14.2	64	14.2	64.0
	22,342.4	127,182.3	2,010.9	11,446.4	10,681.4	14,865.4	628.3	2,949.4	756.8	2,495	14,077.4	31,756.2

B-18 (Cont'd)

NUMBER OF DAMS SORTED BY HEIGHT AND STORAGE CHARACTERISTICS

Maximum Height (Feet)	Maximum Storage (Acre-Feet)			
	0-99	100-999	1,000-9,999	More than 10,000
0-19	214	305	63	18
20-49	144	243	87	34
50-99	9	50	52	39
More than 100	2	6	12	86

NUMBER OF DAMS SORTED BY TYPE AND AGE

Type of Dam	Year Dam Completed			
	Before 1931	1931-1955	1956 to date	Unknown
Earth	265	351	524	0
Rockfill	24	11	19	0
Gravity	40	35	23	0
Buttress	2	7	0	0
Arch	18	10	6	0
Multi-Arch	2	0	1	0
Other	18	5	5	0

REGIONAL HYDROPOWER AND HYDROPOWER POTENTIAL STATISTICS

CALIFORNIA-SOUTH PACIFIC: MAJOR DRAINAGE

	Existing Hydropower Production Facilities		Large Dam Potential (Greater than 5,000 KW Capacity)						Small Dam Potential (Less than 5,000 KW)		Total Basin Potential	
			Rehabilitation Potential (9%)		Hydro Expansion Potential		Hydro Installation Potential					
Basin Name	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)
North Coastal	265.6	1,292.8	23.9	116.3	0	0	116	258.0	Not Available		139.9	374.3
Sacramento	4,409.3	19,675.5	396.8	1,770.8	488.0	1,378.7	114	327.5			998.8	3,477.0
Tulare	386.6	1,920.2	34.8	172.8	200.5	482.0	10	40.0			245.3	694.8
San Joaquin	1,583.2	8,914.9	142.5	802.3	221.5	1,013.0	6	30.0			370.0	1,845.3
Delta Central Sierra	0	0	0	0	0	0	0	0			0	0
San Francisco Bay	0	0	0	0	0	0	0	0			0	0
Central Coastal	0	0	0	0	0	0	0	0			0	0
South Coastal	252.3	981.3	22.7	88.3	59.8	390.0	268	1,649			350.5	2,127.3
South Lahontan	0	0	0	0	0	0	0	0			0	0
Colorado Desert	152.9	615.8	13.8	55.4	0	0	0	0			13.8	55.4
	7,049.9	33,400.5	634.5	3,005.9	969.8	3,263.7	514	2,304.5			2,118.3	8,574.1

NUMBER OF DAMS SORTED BY HEIGHT AND STORAGE CHARACTERISTICS

Maximum Height (Feet)	Maximum Storage (Acre-Feet)			
	0-99	100-999	1,000-9,999	More than 10,000
0-19	90	151	52	17
20-49	181	251	71	21
50-99	51	90	70	32
More than 100	9	17	41	143

NUMBER OF DAMS SORTED BY TYPE AND AGE

Type of Dam	Year Dam Completed			
	Before 1931	1931-1955	1956 to date	Unknown
Earth	293	279	396	0
Rockfill	34	8	14	0
Gravity	48	34	22	0
Buttress	2	1	0	0
Arch	43	13	13	0
Multi-Arch	16	1	0	0
Other	48	11	11	0

REGIONAL HYDROPOWER AND HYDROPOWER POTENTIAL STATISTICS

ALASKA: MAJOR DRAINAGE

	Existing Hydropower Production Facilities		Large Dam Potential (Greater than 5,000 KW Capacity)						Small Dam Potential (Less than 5,000 KW)		Total Basin Potential	
			Rehabilitation Potential (9%)		Hydro Expansion Potential		Hydro Installation Potential					
Basin Name	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)
Arctic	123.2	493.3	11.1	44.4	36.5	141	45.9	238.5	0	0	119	536
Northwest									0	0		
Yukon									0.2	0		
Southwest									0	0		
South Central									14.9	66		
Southeast									10.4	46		
	123.2	493.3	11.1	44.4	36.5	141	45.9	238.5	25.5	112	119	536

NUMBER OF DAMS SORTED BY HEIGHT AND STORAGE CHARACTERISTICS

Maximum Height (Feet)	Maximum Storage (Acre-Feet)			
	0-99	100-999	1,000-9,999	More than 10,000
0-19	2	5	3	0
20-49	3	7	3	3
50-99	0	2	2	2
More than 100	0	0	0	3

NUMBER OF DAMS SORTED BY TYPE AND AGE

Type of Dam	Year Dam Completed			
	Before 1931	1931-1955	1956 to date	Unknown
Earth	2	0	6	0
Rockfill	2	2	3	0
Gravity	1	0	3	0
Buttress	0	0	0	0
Arch	1	2	0	0
Multi-Arch	0	0	1	0
Other	6	4	2	0

REGIONAL HYDROPOWER AND HYDROPOWER POTENTIAL STATISTICS

HAWAII: MAJOR DRAINAGE

	Existing Hydropower Production Facilities		Large Dam Potential (Greater than 5,000 KW Capacity)						Small Dam Potential (Less than 5,000 KW)		Total Basin Potential	
			Rehabilitation Potential (9%)		Hydro Expansion Potential		Hydro Installation Potential					
Basin Name	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)
Hawaii-Hawaii Co.	5.0	34.3	0.5	3.1	0	0	0	0	0.2	0.1	0.7	3.2
Maui	5.2	27.5	0.5	2.5	0	0	0	0	0.5	2.1	1.0	4.6
Kahoolawe	0	0	0	0	0	0	0	0	0	0	0	0
Lanai	0	0	0	0	0	0	0	0	0	0	0	0
Molokai	0	0	0	0	0	0	0	0	6.7	5.9	6.7	5.9
Oahu-Oahu Co.	0	0	0	0	0	0	0	0	20.5	20.3	20.5	20.3
Kauai	7.9	42.6	0.7	3.8	1.3	8.0	0	0	2.6	11.6	4.6	23.4
Niihau	0	0	0	0	0	0	0	0	0	0	0	0
	18.1	104.4	1.7	9.4	1.3	8.0	0	0	30.5	40	33.5	57.4

NUMBER OF DAMS SORTED BY HEIGHT AND STORAGE CHARACTERISTICS

Maximum Height (Feet)	Maximum Storage (Acre-Feet)			
	0-99	100-999	1,000-9,999	More than 10,000
0-19	11	4	0	0
20-49	45	47	3	0
50-99	0	5	3	0
More than 100	0	1	0	0

NUMBER OF DAMS SORTED BY TYPE AND AGE

Type of Dam	Year Dam Completed			
	Before 1931	1931-1955	1956 to date	Unknown
Earth	97	12	9	0
Rockfill	0	0	0	0
Gravity	0	0	0	0
Buttress	0	0	0	0
Arch	0	0	1	0
Multi-Arch	0	0	0	0
Other	0	0	0	0

REGIONAL HYDROPOWER AND HYDROPOWER POTENTIAL STATISTICS

PUERTO RICO-VIRGIN ISLANDS: MAJOR DRAINAGE

	Existing Hydropower Production Facilities		Large Dam Potential (Greater than 5,000 KW Capacity)						Small Dam Potential (Less than 5,000 KW)		Total Basin Potential	
			Rehabilitation Potential (9%)		Hydro Expansion Potential		Hydro Installation Potential					
Basin Name	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)	Capacity (MW)	Output (10^6KWH)
Puerto Rico (all)	None listed				No potential				10.3	128.8	10.3	128.8
Virgin Islands (all)	"	"			"	"			0	0	0	0

NUMBER OF DAMS SORTED BY HEIGHT AND STORAGE CHARACTERISTICS

Maximum Height (Feet)	Maximum Storage (Acre-Feet)			
	0-99	100-999	1,000-9,999	More than 10,000
0-19	2	0	0	0
20-49	6	2	0	0
50-99	0	3	5	2
More than 100	0	1	4	8

NUMBER OF DAMS SORTED BY TYPE AND AGE

Type of Dam	Year Dam Completed			
	Before 1931	1931-1955	1956 to date	Unknown
Earth	3	8	2	0
Rockfill	0	1	0	0
Gravity	2	10	3	0
Buttress	3	0	0	0
Arch	0	0	0	0
Multi-Arch	0	0	0	0
Other	0	0	1	0

APPENDIX C

EXISTING REGIONAL RESERVOIR STORAGE

The following tables summarize the predominate use of existing reservoir storage in each of the major drainage basins of the United States. The reservoir volumes correspond to the maximum available storages behind existing dams in each region and do not account for shared or allocated storage for multiple-purpose reservoirs; i.e., if a reservoir was primarily built for flood control, all available storage has been assigned to the flood control category even though the reservoir is now being used for other purposes as well.

All of the listed purposes of reservoir storage are in a sense competitors with hydropower. If no reallocation of storage were contemplated, then the only water available for hydropower generation would be the currently required minimum releases for downstream flows, water normally spilled prior to or during floods, water automatically released through low-flow conduits, and any other inflows not currently stored or withdrawn for authorized purposes.

Table C-1

REGION: NEW ENGLAND

RIVER BASINS INCLUDED:
St. John-St. Croix
Penobscot
Kennebec-Androscoggin
Saco
Merrimack
Massachusetts-Rhode Island Coastal
Long Island Sound
Connecticut
St. Francis

Total Number of Dams: 2866

Total Maximum Storage: 21.612 (10^6a-f)

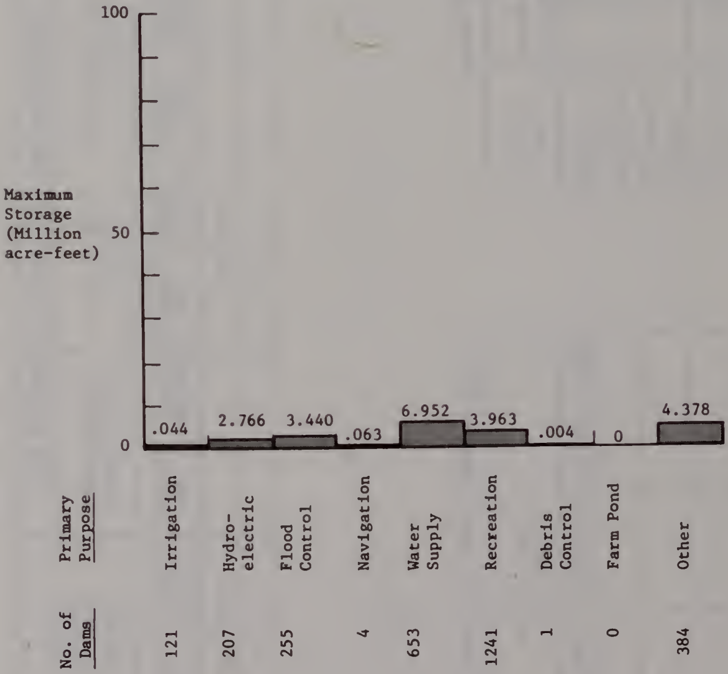


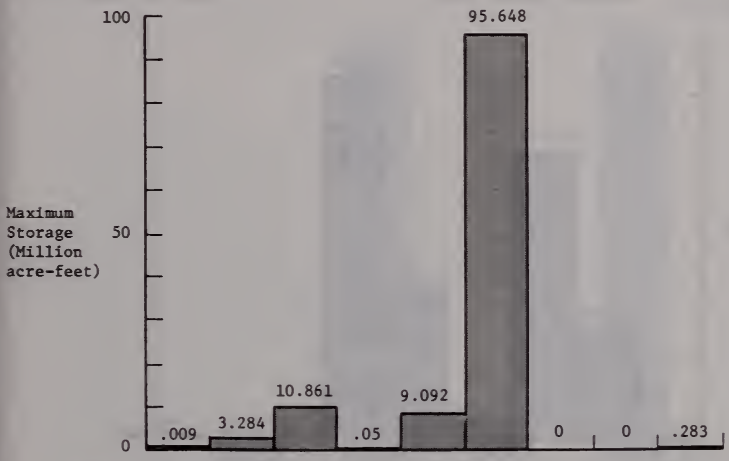
Table C-2

REGION: MIDDLE ATLANTIC

RIVER BASINS INCLUDED:
- Richelieu
- Upper Hudson
- Lower Hudson
- Delaware
- Susquehanna
- Upper Chesapeake Bay
- Potomac
- Lower Chesapeake Bay

Total Number of Dams: 2969

Total Maximum Storage: 119.230 (10^6a-f)



Primary Purpose	No. of Dams
Irrigation	66
Hydro-electric	281
Flood Control	275
Navigation	13
Water Supply	660
Recreation	1499
Debris Control	8
Farm Pond	4
Other	163

Table C-3

REGION: SOUTH ATLANTIC GULF

RIVER BASINS INCLUDED:

Roanoke
Tar-Neuse
Cape Fear
Pee Dee
Santee-Edisto
Savannah-Ogeechee
Altamaha-St. Marys
St. Johns
Southern Florida
Tampa Bay
Suwannee
Ochlockonee
Apalachicola
St. Josephs-Perdido
Alabama
Tombigbee
Pascagoula
Pearl

Total Number of Dams: 6924

Total Maximum Storage: 219.277 (10^6a-f)

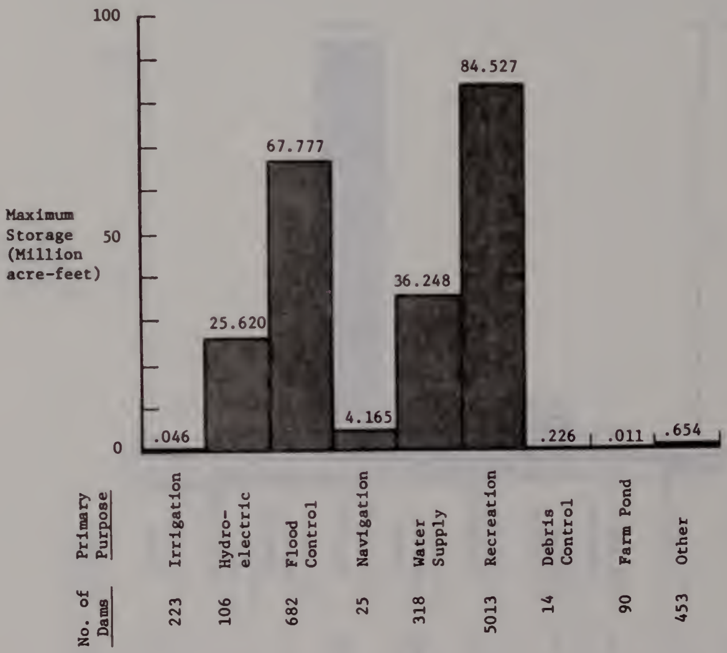


Table C-4

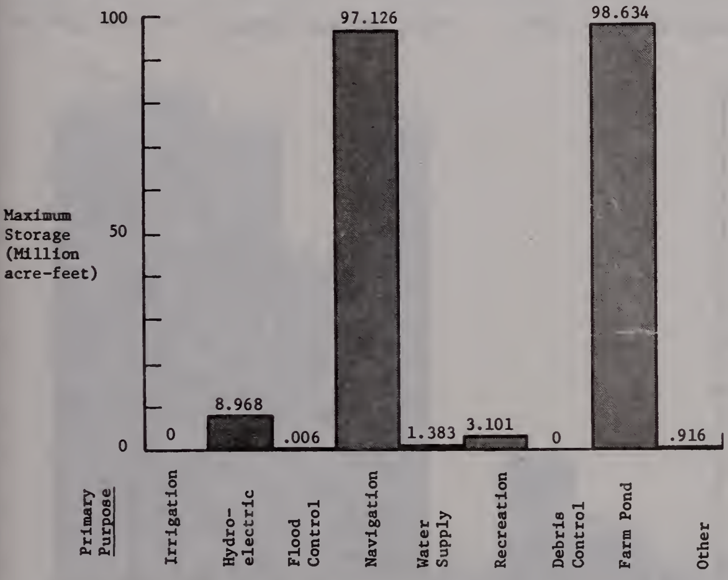
REGION: GREAT LAKES

RIVER BASINS INCLUDED:

Western Lake Superior
Southern Lake Superior
Southwestern Lake Michigan
Southeastern Lake Michigan
Northeastern Lake Michigan
Northwestern Lake Michigan
Northwestern Lake Huron
Southwestern Lake Huron
St. Clair-Detroit
Western Lake Erie
Southern Lake Erie
Eastern Lake Erie
Southwestern Lake Ontario
Southeastern Lake Ontario
Northeastern Lake Ontario-St. Lawrence

Total Number of Dams: 1244

Total Maximum Storage: 210.139 (10^6 a-f)



No. of Dams	
Irrigation	2
Hydro-electric	168
Flood Control	7
Navigation	9
Water Supply	88
Recreation	887
Debris Control	2
Farm Pond	7
Other	74

Table C-5

REGION: OHIO

RIVER BASINS INCLUDED:
Allegheny
Monongahela
Pittsburgh-Wheeling-Beaver
Muskingum
Kanawha
Scioto
Portsmouth-Little Kanawha-Big Sandy
Great Miami
Cincinnati-Little Miami
Licking and Kentucky
Louisville-Salt
White and Patoka
Wabash
Cumberland
Evansville-Green

Total Number of Dams: 2862

Total Maximum Storage: 483.519 (10^6a-f)

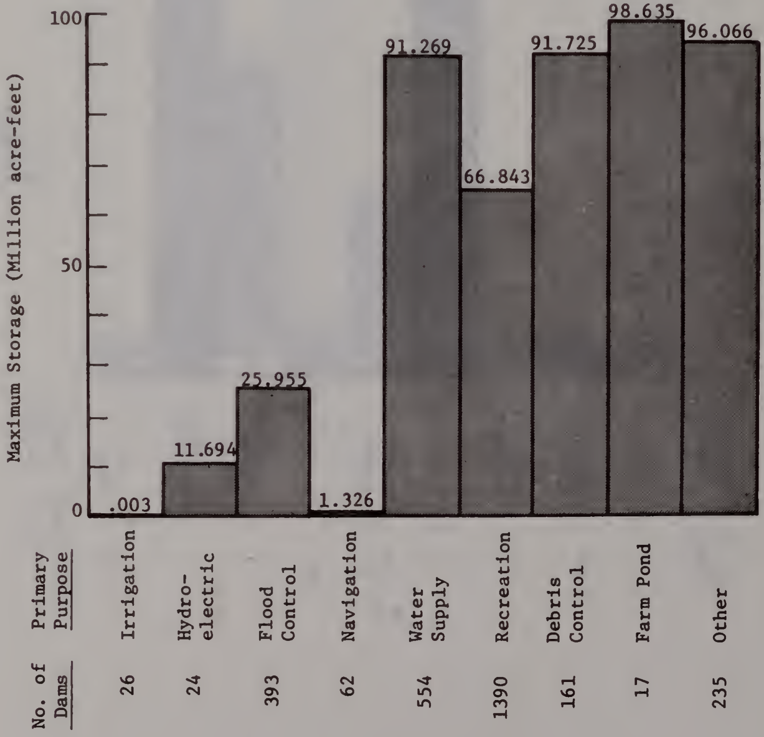


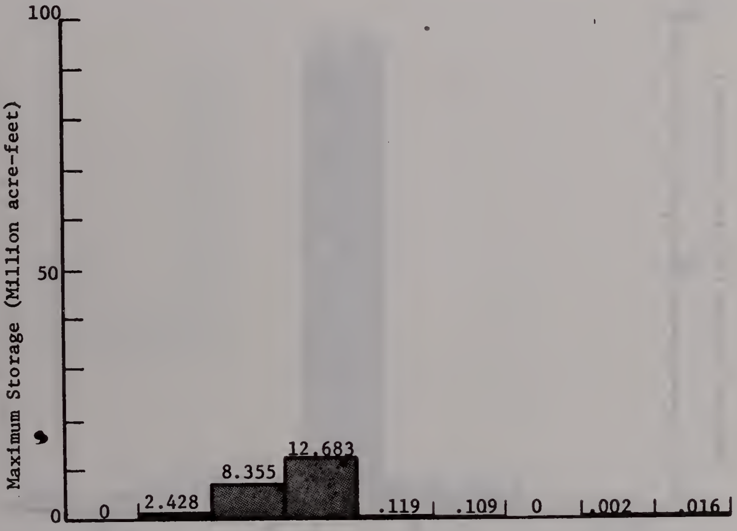
Table C-6

REGION: TENNESSEE

RIVER BASINS INCLUDED:
Upper Tennessee
Tennessee-Hiwassee-Sequatchie
Tennessee-Elk
Lower Tennessee

Total Number of Dams: 459

Total Maximum Storage: 23.712 (10^6a-f)



Primary Purpose	No. of Dams
Irrigation	2
Hydro-electric	33
Flood Control	51
Navigation	10
Water Supply	21
Recreation	282
Debris Control	0
Farm Pond	15
Other	45

Table C-7

REGION: UPPER MISSISSIPPI

RIVER BASINS INCLUDED:
Minnesota
Mississippi Headwaters
St. Croix
Chippewa
Mississippi-Black-Root
Wisconsin
Mississippi-Maquoketa-Plum
Rock
Des Moines
Mississippi-Iowa-Quad Cities
Mississippi-Salt-Quincy
Upper Illinois
Lower Illinois
Mississippi-Kaskaskia-St. Louis

Total Number of Dams: 3329

Total Maximum Storage: 110.672 (10^6a-f)

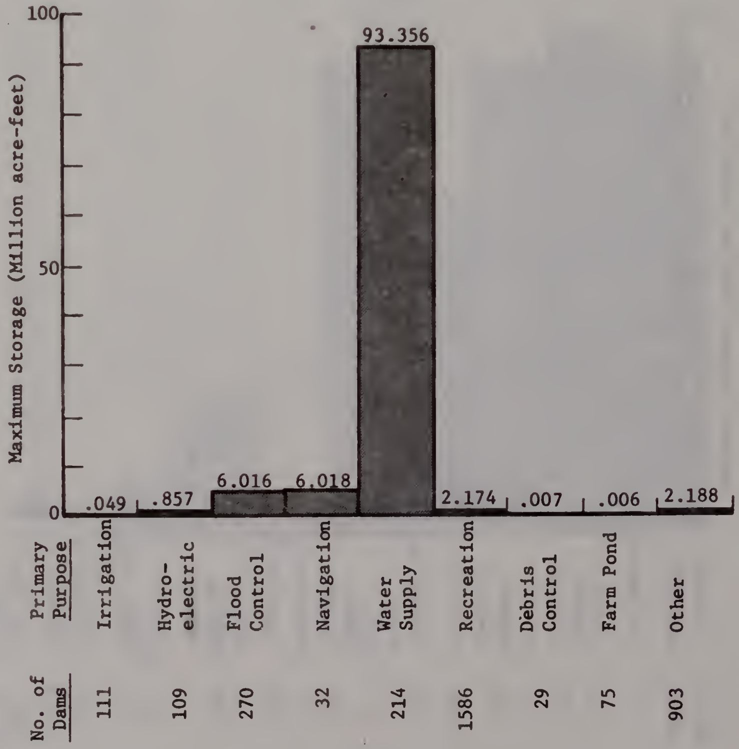


Table C-8

REGION: LOWER MISSISSIPPI

RIVER BASINS INCLUDED:
- Mississippi-Hatchie
- Mississippi-St. Francis
- Mississippi-Yazoo
- Ouachita
- Mississippi-Tensas
- Mississippi-Big Black
- Mississippi-Lake Maurepas
- Louisiana Coastal
- Mississippi Delta

Total Number of Dams: 2559

Total Maximum Storage: 20.191 (10^6a-f)

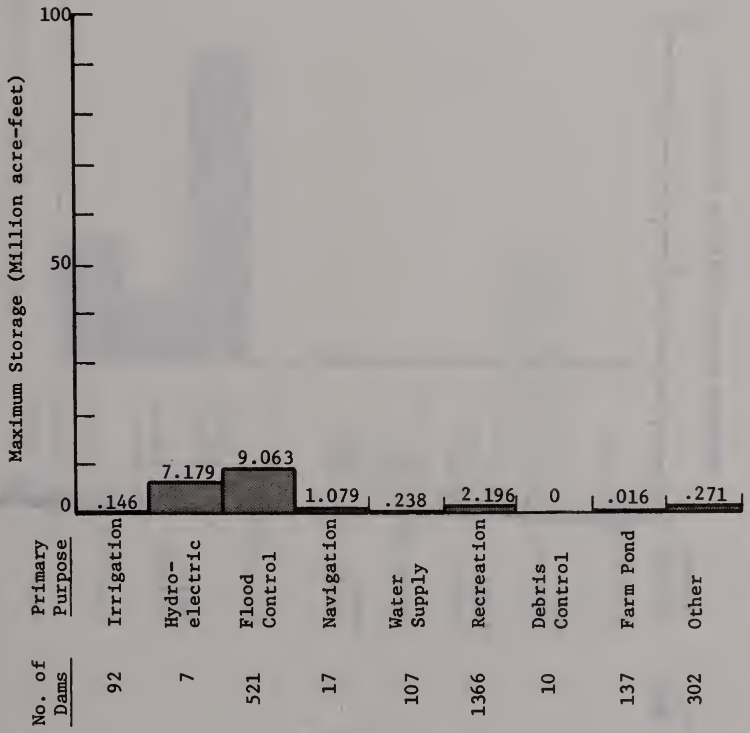


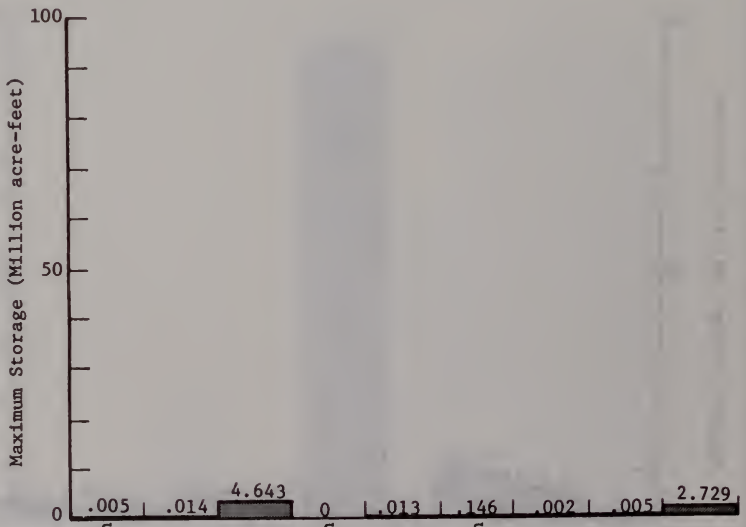
Table C-9

REGION: SOURIS-RED-RAINY

RIVER BASINS INCLUDED:
Souris
Red
Rainy

Total Number of Dams: 304

Total Maximum Storage: 7.558 (10^6a-f)



Primary Purpose	No. of Dams
Irrigation	7
Hydro-electric	9
Flood Control	44
Navigation	0
Water Supply	24
Recreation	76
Debris Control	1
Farm Pond	21
Other	122

Table C-10

REGION: MISSOURI

RIVER BASINS INCLUDED:

St. Mary
Missouri Headwaters
Missouri-Marias
Missouri-Musselshell
Milk
Missouri-Poplar
Upper Yellowstone
Bighorn
Tongue-Powder
Lower Yellowstone
Missouri-Little Missouri
Cheyenne
Missouri-Oahe
Missouri-White
Niobrara
Missouri-Kansas City
James
Missouri-Big Sioux
North Platte
South Platte
Loup River
Platte
Elkhorn
Missouri-Sioux City-Omaha
Missouri-Nemaha-Nodaway
Republican
Smoky Hill
Kansas
Grand-Chariton
Osage-Gasconade

Total Number of Dams: 11,971 Total Maximum Storage: 115.456 (10^6a-f)

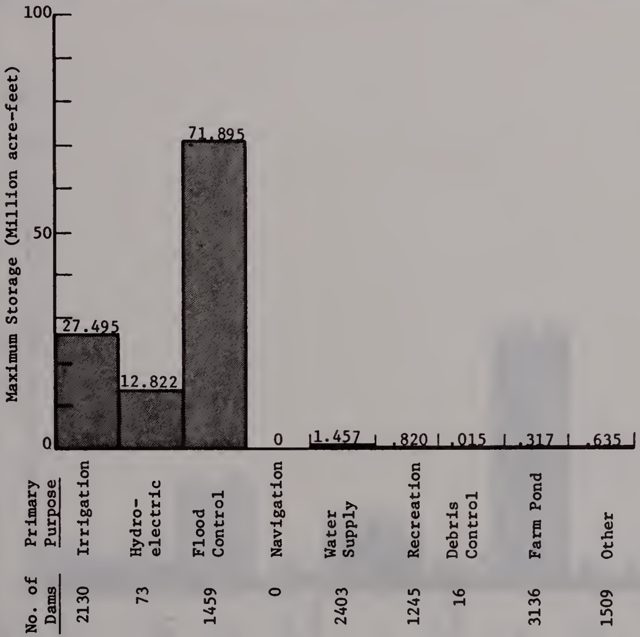


Table C-11

REGION: ARKANSAS-WHITE-RED

RIVER BASINS INCLUDED:
White
Upper Arkansas
Arkansas in Kansas
Upper Cimarron
Lower Cimarron
Arkansas-Keystone
Verdigris-Neosho
Upper Canadian
Canadian in Texas
Lower Canadian
Red River Headwaters
Red-Washita
Lower Red
Lower Arkansas

Total Number of Dams: 5097

Total Maximum Storage: 69.867 (10^6a-f

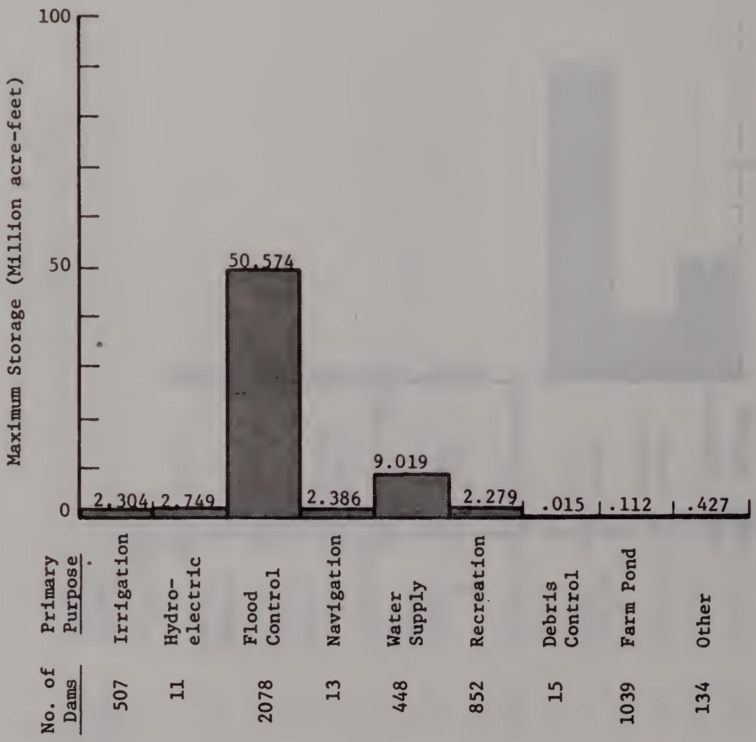


Table C-12

REGION: TEXAS-GULF

RIVER BASINS INCLUDED:
Sabine
Neches
Upper Trinity
Lower Trinity
Brazos Headwaters
Middle Brazos
Lower Brazos
Colorado (Texas) Headwaters
Lower Colorado-Llano
Guadalupe-San Antonio
Nueces-Frio

Total Number of Dams: 3535

Total Maximum Storage: 55.422 (10^6a-f)

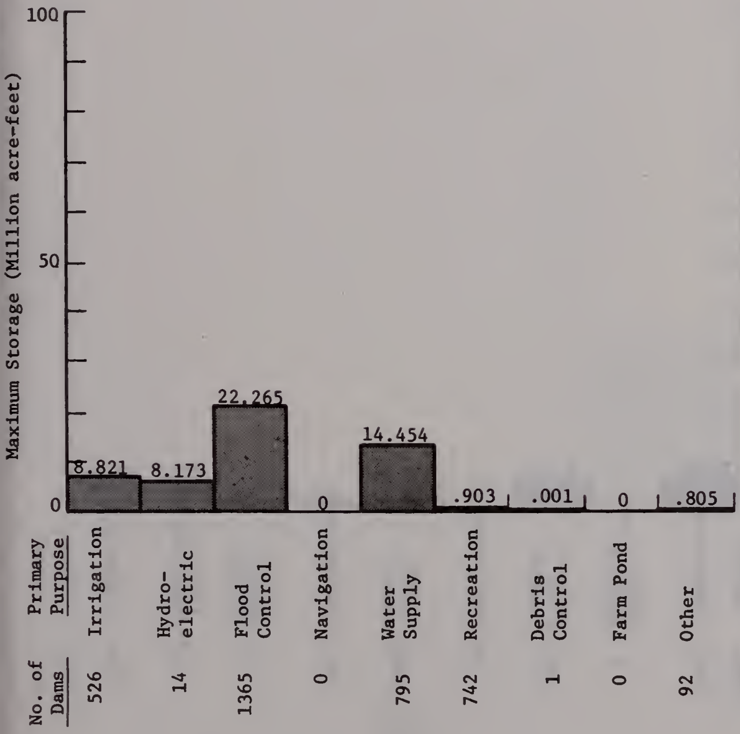


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Table C-13

REGION: RIO GRANDE

RIVER BASINS INCLUDED:
- Rio Grande Headwaters
- North Rio Grande
- Rio Grande-Mimbres
- Rio Grande-Big Bend
- Rio Grande Closed Basins
- Upper Pecos
- Lower Pecos
- Rio Grande-Amistad
- Lower Rio Grande

Total Number of Dams: 448

Total Maximum Storage: 14.411 (10^{6}a-f

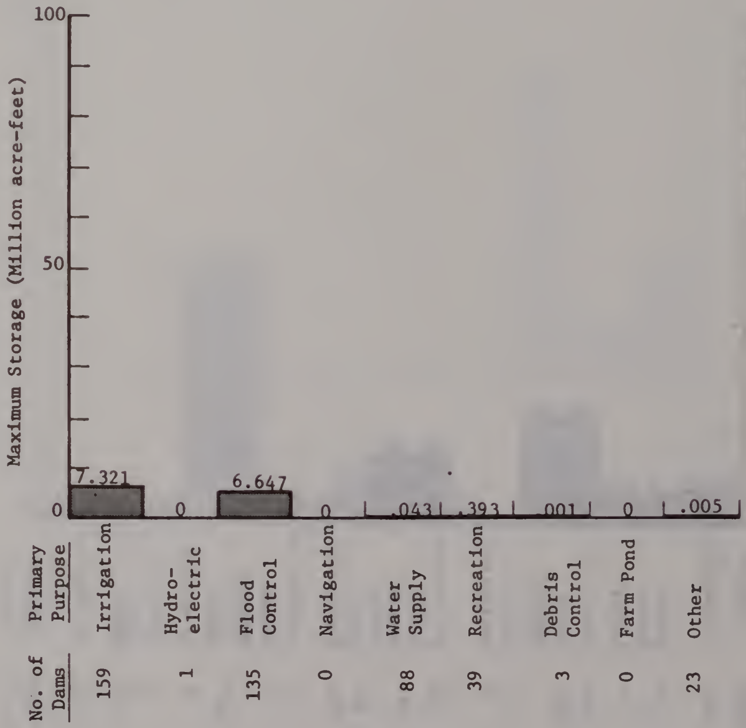


Table C-14

REGION: UPPER COLORADO

RIVER BASINS INCLUDED:
- Upper Green
- Yampa-White
- Lower Green
- Gunnison
- Colorado Headwaters
- Colorado-Dolores
- Upper San Juan
- Colorado-San Juan

Total Number of Dams: 1018

Total Maximum Storage: 12.366 (10^6a-f)

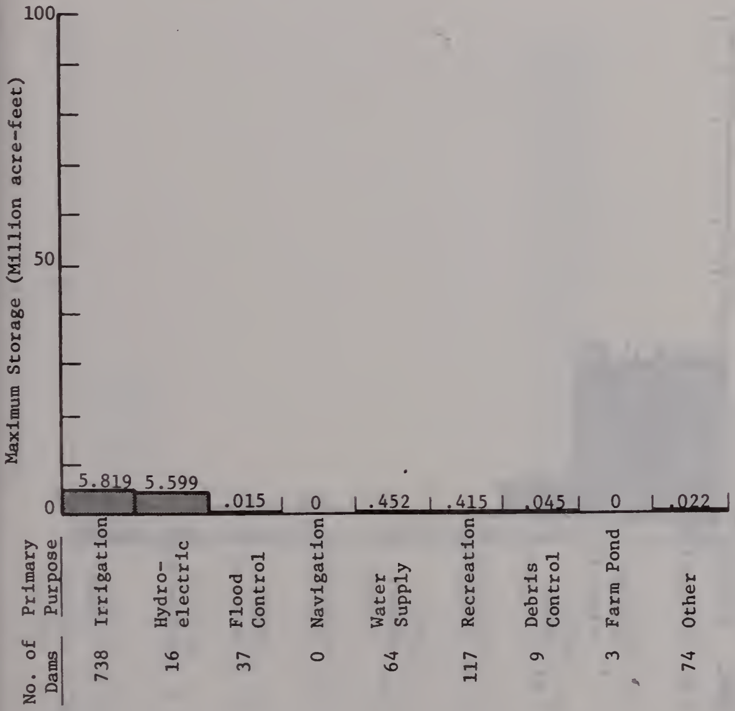


Table C-15

REGION: LOWER COLORADO

RIVER BASINS INCLUDED:
Little Colorado
Colorado-Lake Mead
Upper Gila
Gila-San Pedro
Gila-Salt
Colorado-Lake Mojave

Total Number of Dams: 419

Total Maximum Storage: 72.111 (10^6a-f)

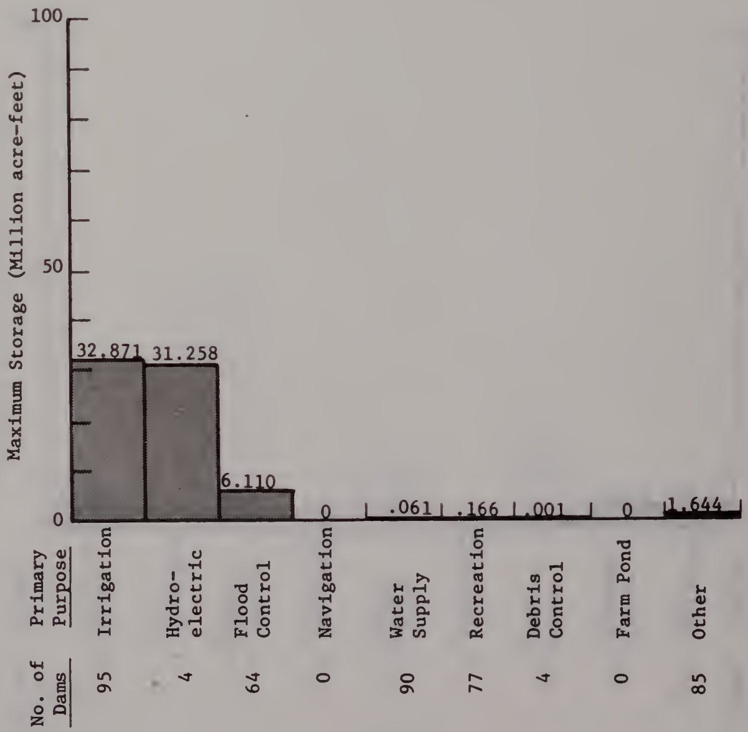


Table C-16

REGION: GREAT BASIN

RIVER BASINS INCLUDED:
Bear
Great Salt Lake
Sevier Lake
Humboldt
Central Lahontan
Tonopah Desert

Total Number of Dams: 436

Total Maximum Storage: 4.200 (10^6a-f)

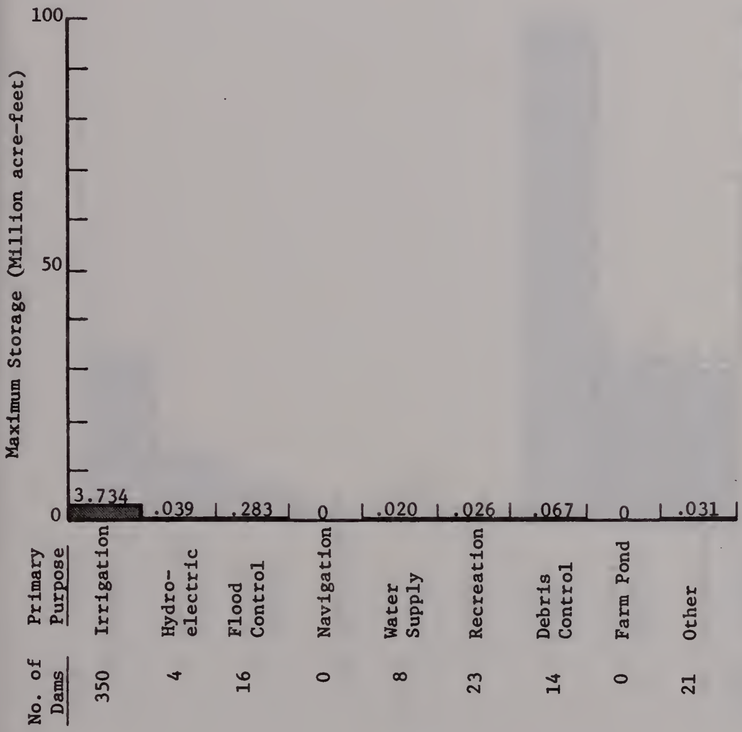


Table C-17

REGION: COLUMBIA-NORTH PACIFIC

RIVER BASINS INCLUDED:

Kootenai
Pend Oreille
Spokane
Yakima
Upper Snake
Middle Snake
Salmon
Lower Snake
Upper Columbia
Deschutes
Middle Columbia
Willamette
Lower Columbia
Puget Sound
Washington Coastal
Oregon Coastal
Oregon Closed Basin

Total Number of Dams: 1364

Total Maximum Storage: 68.007 (10^6a-f)

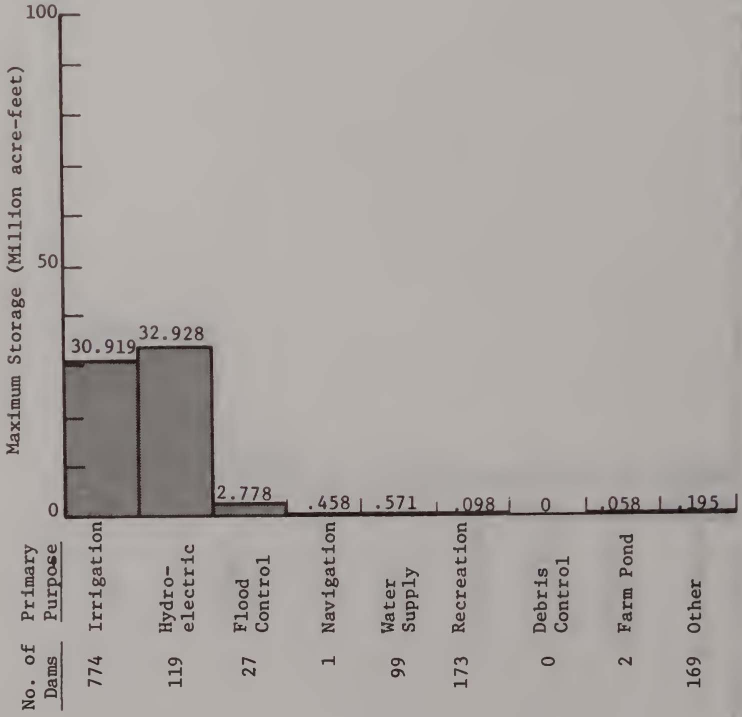


Table C-18

REGION: CALIFORNIA-SOUTH PACIFIC

RIVER BASINS INCLUDED:
North Coastal
Sacramento Basin
Tulare Basin
San Joaquin
Delta Central Sierra
San Francisco Bay
Central Coastal
South Coastal
South Lahontan
Colorado Desert

Total Number of Dams:1249

Total Maximum Storage: 146.163 (10^6a-f)

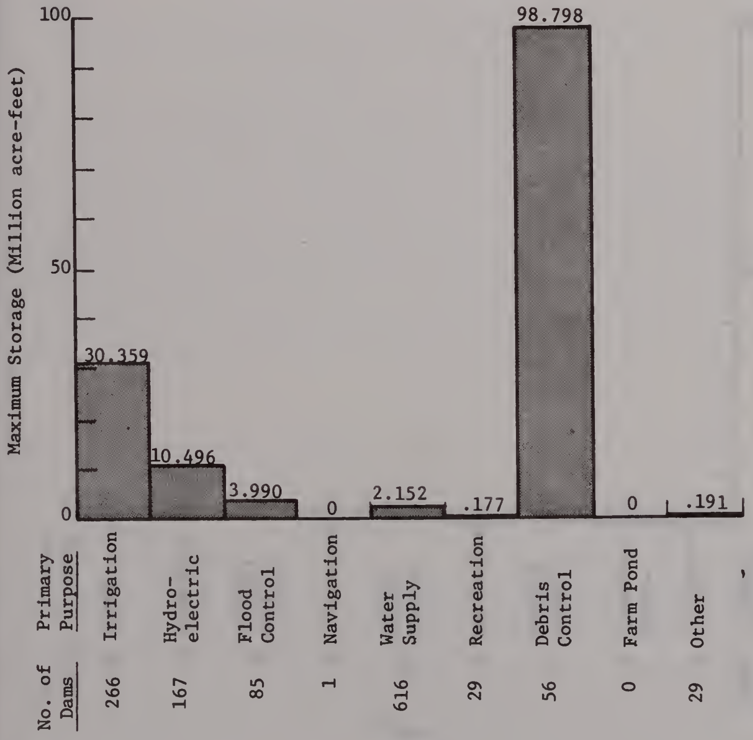


Table C-19

REGION: ALASKA

RIVER BASINS INCLUDED:
Arctic
Northwest
Yukon
Southwest
South Central
Southeast

Total Number of Dams: 35

Total Maximum Storage: .870 (10^6a-f)

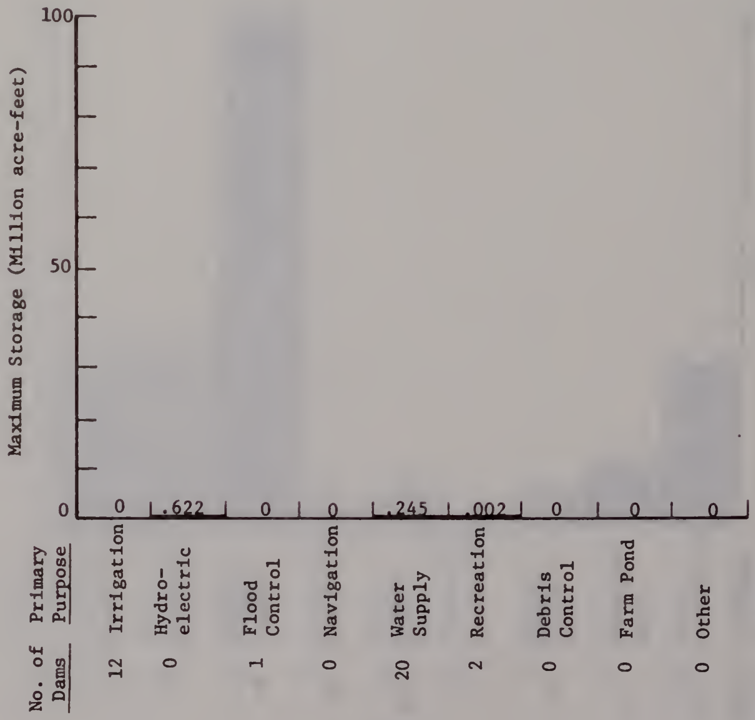


Table C-20

REGION: HAWAII

RIVER BASINS INCLUDED:
Hawaii-Hawaii Co.
Maui
Kahoolawe
Lanai
Molokai
Oahu - Oahu Co.
Kauai
Niihau

Total Number of Dams: 119

Total Maximum Storage: .053 (10^6a-f)

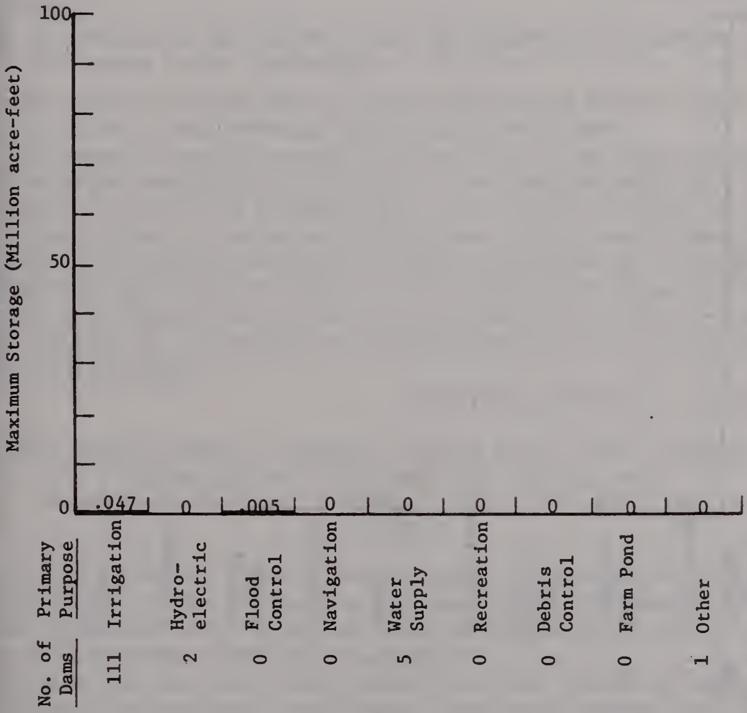


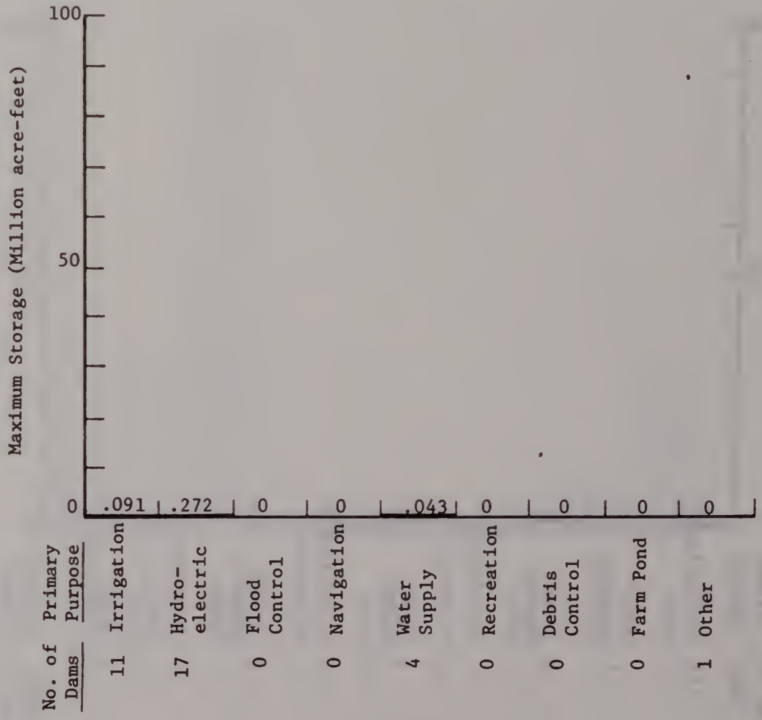
Table C-21

REGION: PUERTO RICO & VIRGIN ISLANDS

RIVER BASINS INCLUDED:
Puerto Rico
Virgin Islands

Total Number of Dams: 33

Total Maximum Storage: .406 (10^6a-f)



A REPORT BY THE U.S. GENERAL ACCOUNTING OFFICE, MARCH 1977

Power Production at Federal Dams Could be Increased by Modernizing Turbines and Generators

Existing Federal hydroelectric plants could increase power production by modernizing turbines to increase efficiencies and capacities and by modernizing generators to increase capacities.

Increasing hydroelectric power production will (1) increase the Nation's energy supply, (2) displace consumption of nonrenewable fuels by fossil-fueled power plants, (3) reduce pollution, (4) increase Federal revenues, and (5) displace or delay construction of alternate power sources.

Federal agencies that operate hydroelectric plants should evaluate existing plants to identify and act on these opportunities.

U.S. General Accounting Office,
Energy and Minerals Division,
Washington, D.C.

B–125042

To: Secretaries of the Interior and the Army and Chairman of the Tennessee Valley Authority.

This report discusses how power production at Federal dams could be increased by modernizing turbines and generators.

This report contains recommendations to you on pages 10 and 11. As you know, section 236 of the Legislative Reorganization Act of 1970 requires the head of a Federal agency to submit a written statement on actions taken on our recommendations to the House Committee on Government Operations and the Senate Committee on Governmental Affairs not later than 60 days after the date of the report and to the House and Senate Committees on Appropriations with the agency's first request for appropriations made more than 60 days after the date of the report.

Monte Canfield, Jr., *Director.*

Power Production at Federal Dams Could Be Increased by Modernizing Turbines and Generators

DIGEST

At some existing Federal powerplants potential exists to increase hydroelectric power production by: modernizing turbines to increase their efficiencies and capacities, and modernizing generators to increase their power producing capacity.

It may be cost and energy effective to the Nation for agencies to modernize hydroelectric machinery. Increased hydroelectric power production displaces oil and coal consumption, thus contributing to energy conservation and pollution reduction; it may also displace or delay construction of alternate power sources and increase Federal revenues.

Opinions vary among agency engineers, manufacturers' engineers, and independent engineers as to the extent of increases that can be gained and whether evaluation and implementation of opportunities is worthwhile. Engineering estimates of increased efficiency for plants that might be improved vary from 1 to 2 percent to 5 to 10 percent.

At existing plants where worn out turbine and generator components have been replaced with modern components, efficiency and capacity increases were possible through design improvements. In these instances efficiencies have been increased as much as 8 percent and capacities increased as much as 36 percent.

The increases from design improvements were of such importance that replacing components at other plants, before they wear out, may be economical.

The three Federal agencies having major hydroelectric power operations—the U.S. Army Corps of Engineers, the Department of the Interior's Bureau of Reclamation, and the Tennessee Valley Authority—do not have systems to evaluate these opportunities and in the past have not studied such opportunities on a system-wide basis.

Detailed analysis at each power plant is needed to determine what modernization improvements might be made and if they would be cost effective.

GAO recommends that the agencies evaluate opportunities to improve hydropower production and act on those that are economically justified. The value of displaced fossil-fuel consumption by increased hydropower production should, we believe, be considered in the evaluation.

CHAPTER 1.—INTRODUCTION

About 15 percent of the Nation's electric-generating capacity [1] is hydroelectric and about 40 percent of this hydroelectric capacity is Federally owned.

Three Federal agencies have major hydroelectric operations—the U.S. Army Corps of Engineer (Corps), the Department of the Interior's Bureau of Reclamation (Bureau), and the Tennessee Valley Authority (TVA). As of July 1, 1975, these agencies operated 152 hydroelectric power plants with an average annual output of about 124 billion kilowatt-hours.[2] About 206 million barrels of oil would be needed to produce an equivalent amount of electricity.

Hydroelectric power is produced by channeling dammed water through turbines, which drive generators that produce electric current. The current is then sent over high-voltage transmission lines to points of use.

Water released through a turbine applies force against turbine blades. The turbine blades drive a shaft which turns an electric generator. The generator converts mechanical energy into electric energy producing electric current. Each step in this energy conversion process affects the efficiency of conversion and reduces the energy output of the system. Efficiency is the ratio of output energy to input energy. In hydroelectric plants, it is the amount of electric energy produced compared to the energy released to the turbines. Thus, the combined efficiencies of each system component is the system's overall efficiency. Improving the efficiency of any one component will increase the system's overall efficiency.

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[1] Rated power output of a turbine, generator, or power plant.
[2] One kilowatt-hour equals 1,000 watt-hours.

Turbine design depends on the conditions under which it is used such as reservoir levels, water flow, and power demands. Therefore, most turbines are specifically designed to meet the conditions at the dam site.

Scope of review

We made our review at the Bureau of Reclamation's Mid-Pacific region, Pacific Northwest region, and Engineering and Research Center; the Corps' Headquarters and North Pacific Division; and at TVA offices in Tennessee. We interviewed agency officials and engineers at each location and reviewed pertinent agency program documents, records, correspondence, and reports. We also contacted several manufacturers' engineering representatives, as well as several independent engineers experienced in hydroelectric machinery, for information and technical opinions.

CHAPTER 2.—OPPORTUNITIES TO INCREASE HYDROELECTRIC POWER PRODUCTION AT EXISTING FEDERAL DAMS BY MODERNIZING TURBINES AND GENERATORS

Technological advances since the 1930s, when the Government first became substantially involved in hydroelectric power, have resulted in improved turbine and generator designs and materials. Because of these advances, potential exists at some Federal hydroelectric plants to increase power production. These increases can be achieved by modernizing turbines and generators to improve plant efficiency and maximize power production.

The Bureau of Reclamation, the Corps of Engineers, and TVA make improvements in existing turbines and generators when major components fail or deteriorate. However, because of the long useful life of the components and the Nation's increased energy needs, it may now be worthwhile to make efficiency and capacity improvements before the turbine and generator components wear out.

The three agencies have not identified and evaluated the potential to increase power production in their power systems through turbine and generator modernization, and have not established review systems to identify the advantages of implementing technological advances at existing dams.

Bureau, Corps, and TVA officials agreed in concept that efficiencies and capacities may be increased at some plants by modernizing turbines and generators. However, the Corps believes that it is too expensive and that opportunities for improvements are slight at its dams. A Corps official said the best opportunities to increase efficiencies and capacities would be at dams where operating conditions have changed. Bureau and TVA officials agreed that it would be worthwhile to make preliminary studies to identify potentials. Officials of all three organizations agreed that their agencies have no existing system to review technological improvements, and that studies should be made to determine the potential to increase power production through modernization. As a result of our discussions with the Bureau, instructions were issued to field offices to investigate the financial feasibility of (1) increasing plant efficiency by replacing turbine runners, (2) increasing power plant output by increasing the operating capacity of the generators, and (3) any other methods of increasing efficiency and output.

Each power plant must be individually evaluated in detail by skilled engineers to determine whether any improvements can be made. Improving capacity in turbines may require capacity improvements in both the generator and auxiliary equipment to utilize the increased capacity. Thus, an evaluation of benefits and costs can be made only after careful engineering analysis at each location.

Turbine efficiencies and capacities can be improved

One way to improve plant efficiency is to improve the capability of its turbines.

Although efficient when compared to other energy producers, older hydraulic turbines usually were not of optimal design because of the state of the art of turbine hydraulics, engineers' inexperience in designing turbines, and lack of tools to make precise calculations. From the early 1930s to the early 1950s, engineers gradually improved turbine designs as they gained knowledge and experience and as they improved analytical techniques. As computers became available, further design refinements were possible. By 1970 the state of the art in turbine hydraulics had advanced so that significant efficiency and capacity improvements, according to manufacturers, are possible in many older turbines by replacing runners[1] and other components with more modern ones.

Opinions varied among agency engineers, manufacturers' engineers, and independent engineers as to the extent of increases that can be gained and whether evaluation and implementation of opportunities would be worthwhile. Engineering estimates of increased efficiency for plants that might be improved varied from 1 to 2 percent to 5 to 10 percent. Engineers could not give general estimates of capacity increases because increases vary too much with each plant's design and particular operating conditions.

Engineers cited the following improvements that individually, or in combination, could greatly increase turbine output.

—Increasing maximum efficiency through more modern runner designs.

—Correcting turbine designs to match actual water conditions. (Some plants were built based on projected water conditions that did not materialize; thus, the turbine design is not properly matched to the water flow.)

—Changing the designs of runners where operations have changed to providing peak load power, so that best efficiency occurs nearer maximum output.

—Restoring deteriorated runners.

—Increasing turbine capacity for better efficiency at high load points.

—Replacing adjustable-blade propeller runners with fixed-blade propeller runners where head[2] variation is normally within about ±5 feet. Fixed-blade runners have higher efficiency than adjustable-blade runners for such a small head range.

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[1] Runner—the rotating assembly of a hydraulic turbine that includes the turbine's blade.

[2] Difference in the height of the water at the reservoir level (level behind the dam) and at the point where the water enters the turbine. The greater the distance the water falls before it hits turbines the greater the energy.

- —Installing improved wicket gates,[3] self-lubricating gate bearing materials (which also reduce maintenance), seals, and stay rings.
- —Using improved aerating techniques (pumping air behind seals to improve water going through turbines instead of around them).

Corps engineers said that perhaps the best potential to increase turbine efficiency and capacity is at plants where operating conditions have changed from those of the original design.

Examples of improved efficiency and/or capacity by runner replacement

The following examples illustrate efficiency and capacity improvements that are achievable by modernizing turbines. We believe the increases resulting from design improvements are of such significance that replacing components before they wear out may be economical, especially at plants now being used to produce peak load energy.

Hoover Dam—Operated by the Bureau of Reclamation

Hoover Dam is an example of demonstrated efficiency and capacity increases. In 1970 the Bureau replaced four turbine runners at Hoover, because they were in poor condition and required excessive maintenance. Field tests before and after the new runner installations showed that efficiency improved 6 to 7.5 percent over a broad range of gate openings. Bureau and manufacturer's engineers attribute much of the improvement to restoration of the deteriorated condition but say that perhaps 1 to 2 percent is due to design improvements. However manufacturer's tests show that performance could be considerably improved due to possible design changes, capacity increased up to 10 percent, and efficiency at previous maximum horsepower increased up to 8.6 percent.

A Bureau official in the Lower Colorado region projected efficiency increases of about 4 percent for the other turbines if runners are replaced. He estimated a 4-percent increase would produce an extra 140 million kilowatt-hours of electricity each year.

This extra electricity, if it displaced oil, would save about 233,333 barrels of oil a year (at 600 kWh/barrel).

Shasta Dam—Operated by the Bureau of Reclamation

Shasta Dam is an example of potential efficiency increases. Mid-Pacific region engineers studied Shasta turbines in 1975 and determined peak efficiency could be improved about 3 percent—2 percent due to turbine design improvements and 1 percent from matching the turbine to actual water conditions. According to a region official, turbine modernization for Shasta has been submitted for consideration in the regional budget proposal but has not yet been included because higher priority items have taken precedence.

Fort Peck Dam—Operated by the Corps of Engineers

Fort Peck Dam is an example of potential capacity increases. Engineers at the Corps' Omaha District told us they have recently completed a study of the Fort Peck Dam in Montana. The study indicated that runner replacement could increase turbine capacity from 5 to 12 percent at both high and low reservoir water levels.

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[3] Mechanical gates at the periphery of the turbine runner that control the amount of water delivered through the turbine.

Secretaries of the Interior and the Army and the Chairman of the Board of the Tennessee Valley Authority need to identify opportunities for modernization of hydroelectric machinery and identify costs and benefits in detail.

We believe modernizing existing equipment is worth considering as an alternative or an addition to expanding power operations at existing dams.

Recommendations

We recommend that the Secretaries of the Interior and the Army and the Chairman of the Board of the Tennessee Valley Authority:

—Identify opportunities to improve hydropower production through equipment modernization, and implement those that are economically justified, and consider making changes before the end of the equipment's (or its components') useful life.

—Include in the economic analysis, (1) the value of oil or coal consumption displaced and (2) either directly or indirectly, the value of maintenance costs reduced by installing new equipment.

—Include feasible turbine and generator modernization in their overall hydroelectric power expansion plans.

—Develop systems to make sure that future technological improvements are recognized and considered for implementation in existing systems.

APPENDIX I

FEDERAL HYDROELECTRIC POWER PRODUCTION [1]

Agency	Plants	Power units	Total installed capacity [2] (kilowatts)	Total average annual power production (megawatt-hour)	Equivalent energy in barrels of oil consumed [3]
Bureau	30	180	7, 877, 906	[4] 34, 530, 900	57, 551, 500
Corps	73	315	16, 715, 705	[5] 75, 888, 801	126, 481, 335
TVA	29	109	3, 297, 930	[6] 13, 455, 530	22, 425, 883
Total	152	604	27, 891, 541	123, 875, 231	206, 458, 7185

[1] Does not include 49,000 kW of installed hydroelectric power (as of 1965) from plants operated by 3 other Federal agencies (International Boundary and Water Commission, Bureau of Indian Affairs, and the National Park Service).

[2] Bureau as of July 1, 1975, corps as of Aug. 31, 1975, and TVA as of Aug. 26, 1975.

[3] The approximate amount of oil it would take to produce an equivalent amount of electricity by an oil-fired steam plant, based on a conversion ratio of 600 kWh a barrel of oil consumed.

[4] Average of the totals of production at each plant over its history of operation to July 1, 1975.

[5] Average of the totals of production at each plant from fiscal years 1971 to 1975 (only available data).

[6] Average of the totals of production at each plant since 1946 or data of initial operation (if later) to April 25, 1976.

A DIALOGUE ON VEHICLES BETWEEN HON. JAMES G. MARTIN AND SECRETARY OF ENERGY SCHLESINGER, BEFORE THE HOUSE AD HOC COMMITTEE ON ENERGY, MAY 5, 1977

Mr. MARTIN. Mr. Secretary, turning to another matter which may be more appropriate when we get to the detailed hearings, I would like to ask you about the fuel efficiency tax—I believe that is section 1201—and ask you whether you exempt the 8-passenger van, or do you penalize that because of its low miles per gallon?

Mr. SCHLESINGER. The van is not exempted. If the van is used to form a vanpool, it is eligible for the rebate; so if its purpose is to be used in a vanpool, then it would enjoy a rebate; so it would be in effect untaxed.

Mr. MARTIN. Do you calculate that on passenger miles per gallon?

Mr. SCHLESINGER. Yes, sir. In the case of the van, the applicability of the tax depends on the purpose for which the van is used. We do not want to drive people to purchasing vans as a way of avoiding the tax on fuel inefficient cars.

Mr. MARTIN. Do you make the same allowance for the 6- or 8-passenger station wagon?

Mr. SCHLESINGER. No, sir, we do not make that kind of allowance, but once again, the station wagon we would expect for the foreseeable years ahead can be fuel efficient. It will not have high acceleration, but with an appropriate engine it can meet the Government standards and thus not be subject to the tax.

Mr. MARTIN. You are confident that can be done and will be done, and therefore this will not penalize the family with a number of children and require them to use a smaller automobile with twice as many trips to get the job done?

Mr. SCHLESINGER. We will watch that very carefully. It is clear in the years ahead that there is no risk of that being required.

Mr. MARTIN. I notice you give the electric car arbitrarily the highest rebate of any other automobile.

Mr. SCHLESINGER. Not arbitrarily, sir; by logic I would hope.

Mr. MARTIN. I would say that in the language there, if it is an electric car, if it meets the definition of an electric car, regardless of whether it is efficient or inefficient, regardless of how many barrels of oil equivalent it takes to generate the electricity to run that car a certain number of miles, it is going to get the rebate; is that correct?

Mr. SCHLESINGER. The electric car tends to be a highly efficient vehicle in terms of fuel consumption, but the main point is our basic objective to reduce petroleum consumption, gasoline consumption. There is nothing better than the electric car to do so. I would hope over the years part of the changing pattern will be that the American people come increasingly to use the electric car as a second vehicle for commutation purposes.

Mr. MARTIN. I think your goal in reducing oil consumption is a remarkably good one, but I wonder if the use of coal to generate the electricity to run the electric car would not work just as well by providing some incentive which I don't think we have here to encourage coal to be converted to liquid and gaseous fuel.

Mr. SCHLESINGER. We will check the numbers and insert them in the record, Mr. Martin, and give you a special letter on those numbers with regard to the relative use in Btu's of the various mechanisms that you have suggested.

Mr. MARTIN. That is with regard to the electric car?

Mr. SCHLESINGER. Yes, sir, and the alternatives that you have mentioned.

Mr. MARTIN. That will be very helpful and I would like it to be measured in terms of the oil equivalent that it takes to generate.

Mr. SCHLESINGER. Yes, sir.

There is one other aspect, however, to the electric car. We assume those automobiles will be charged at night and that means that they will be off-peak power. We will not require any greater investment in electric power production capacity as a result of using offpeak power for charging those automobiles.

That will reduce our requirement for capital, and we will otherwise have a very high requirement for capital in the years ahead.

INTRODUCTION TO THE ERDA ELECTRIC AND HYBRID DEMONSTRATION PROGRAM

I. BACKGROUND ELECTRIC AND HYBRID VECHICLE RESEARCH, DEVELOPMENT AND DEMONSTRATION ACT OF 1976:

Public law 94–413 was enacted on September 17, 1976, by Congressional override of a Presidential veto. The Act authorizes in the Energy Research and Development Administration a Federal program of research, development, and demonstration designed to promote electric and hybrid vehicle technologies and to demonstrate the commercial feasibility of electric and hybrid vehicles. It is required that the Electric and Hybrid Vehicle Research, Development and Demonstration Project be established as an organizational entity in ERDA; that research and development be conducted on electric and hybrid vehicles; that a two-part demonstration involving up to 7,500 vehicles be conducted; that certain specified studies be conducted; and that a program of financial incentives involving planning grants and loan guarantees be implemented. The requirements of the Act are in addition to an established base program on electric and hybrid vehicles within ERDA, planned to advance the technology of components and vehicular systems. The legislative history of this Act is summarized in Chapter II which also contains the ERDA position at Congressional testimony supporting the research and development objectives but expressing reservations about the timing of the large-scale demonstration.

The electric car industry in the United States today is in its infancy, consisting entirely of small businesses, the largest of which has produced only 2,000 cars over the last several years. The market is not yet large enough to interest the large Detroit auto makers. The situation is different in Europe and Japan where the major vehicle manufacturers are actively involved in development programs. Except in Japan where significant electric automobile development is underway, the first foreign market perceived is the van or truck for postal and other delivery services. These countries, of course, do not have the two- and three-car families as does the United States; thus the personal automobile may become a viable electric car market much earlier in the United States than overseas. The industry is characterized in Chapter III.

Current electric cars typically have ranges of 20–40 miles between 8-hour recharges, and a few models are currently commercially available. Hybrid vehicles are at an earlier stage of development, and none are commercially available. Notwithstanding the severe limitations of today's electric and hybrid vehicles, the potential for performance improvements and petroleum savings of such advanced technology vehicles is large. This is described in greater detail in Chapter IV. Public Law 94–413 plus the ERDA base program in support of electric and hybrid vehicles can significantly influence the advancement of technology. Powertrain efficiency gains can double vehicle range. Energy storage system technology promises to at least double the range of vehicles in 5 years and, to more than triple the current range in 7–8 years. These potentials are more fully described in Chapter V. The transfer of Government-supported technologies into the small electric and hybrid companies, including the establishment of their engineering competence, has been given serious consideration and is judged to be completely feasible and practical. The judgment is based on patterns already established in the commercial systems and subsystems industries working with ERDA. The conventional pattern is for systems builders to infuse new technology into small companies to competitively supply components. A somewhat less-used pattern is for a high-technology subsystems developer to infuse new technology into the systems builders industry. This latter approach is applicable under the Act, with ERDA working through the best high-technology subsystem and component firms to accelerate the development of new technologies. Emerging vehicle systems builders can then draw on the accelerated technology through acquisition of improved competitively developed components, technology reports, and specifications. Further feedback to both systems and component developers will be provided through dissemination of user data from the demonstration program. More detail is provided in Chapter VI.

An approach for implementation of the financial incentives for small business and loan guarantees as well as studies into other incentive areas as authorized in the legislation is discussed in Chapter VII.

The vehicle demonstrations are the largest and most visible aspects of the project. The early demonstration of up to 2,500 vehicles has the risk of adverse impact on electric car acceptance, since only currently available, marginal performing vehicles will be available. Extreme care in the planning and execution of this phase may prevent negative effects. Proper R&D plus good planning of the second (5,000 vehicle) phase can result in successful demonstration of acceptable performing vehicles, thus achieving the intended purpose of the demonstration. Planning and execution are therefore crucial, with a well developed plan being the premium activity in the initiation of the program. Important factors in the plan are the number and selection of demonstration sites, data requirements, vehicle user mix, financial arrangements, etc., as more fully discussed in Chapter VIII. Servicing and maintenance centers and adequate infrastructure requirements must be carefully established to support the demonstration and eventual commercialization. This aspect is discussed more fully in Chapter IX. Also of high significance to the supplier are the safety considerations and requirements of the vehicle discussed in Chapter X.

Major factors such as market demand, investment in facilities, and infrastructure development that will influence the development of the electric and hybrid vehicle industry after completion of the research, development and demonstration programs are detailed in Chapter XI. These factors are important considerations for initial planning and implementation of the total ERDA program.

As required by the Act, the Electric and Hybrid Research, Development and Demonstration Project has been established as an entity within the Division of Transportation Energy Conservation. The EHVP organization is presented in the Appendix A.

II. LEGISLATIVE HISTORY AND ERDA TESTIMONY BACKGROUND LEGISLATIVE PROPOSALS

Background legislative proposals

The first bills dealing with electric vehicles were introduced in the 89th Congress. On September 13, 1966, Mr. Ottinger introduced a bill to authorize a program of research, development, and demonstration of electrically powered vehicles. Also that year, other related bills were introduced in the House by Mr. Rogers and in the Senate by Messrs. Magnuson, Muskie, and Randolph. None of those bills were passed.

In the 90th Congress, several bills were introduced again in the House that would authorize a program of research, development, and demonstration of electrically powered vehicles. Hearings were held in 1967 on the companion Senate bill introduced by Messrs. Magnuson and Muskie on January 17, 1967. None of these bills were passed.

Antecedent bills

In the 94th Congress on March 25, 1975, H.R. 5470, The Electric Vehicle Research, Development, and Demonstration Act of 1975, was introduced by Messrs. McCormack, Brown, Teague, Mosher, and Goldwater. The widespread interest in the Congress for accomplishing the goals of this legislation was demonstrated by the fact that four bills identical to H.R. 5470 were sponsored by 65 members during the period April through June. These bills were referred to the House Committee on Science and Technology. A companion bill, S. 1632, was introduced in the Senate on May 5, 1975, by Messrs. Moss and Humphrey and was referred to the Senate Committee on Commerce. All bills were three years in duration and provided for management by ERDA of a $40 million per year demonstration and simultaneous basic research program. The primary emphasis was on near-term, large-scale demonstration and simultaneous basic research program calling for production of 5,000 electric vehicles in the first year and 5,000 more in three years.

Hearings and ERDA testimony

Hearings on H.R. 5470 were held on June 3–6, 1975, by the House Science and Technology Subcommittee on Energy R.D. & D. Testimony was presented by witnesses representing government agencies, universities, large vehicle manufacturers, small businesses, and individuals, and was supplemented by written statements. ERDA testimony was presented by Dr. James Kane who testified against the bill, primarily because of its too-much too-soon demonstration, but in favor of the intentions of the bill. At the hearings, Dr. Kane was asked to provide lists of electric vehicle and motor manufacturers and an assessment of life-cycle costs and, in addition, for positive comments to subcommittee staffs on modifications to the bill. The hearings were monitored by ERDA personnel and the required information was supplied subsequently. On June 10, Dr. Kane and personnel from the Division of Transportation Energy Conservation and Congressional Relations met with Congressman Mike McCormack and four staff members, at the Congressman's request, to discuss ERDA recommendations. The Subcommittee on Energy R.D. & D met on July 16 to mark-up H.R. 5470, and reported out a clean bill, H.R. 8800. The full committee met on July 28 and by voice vote unanimously approved the bill and recommended passage by the full House of Representatives. H.R. 8800 passed the House on September 5, 1975.

ERDA provided in writing answers to sets of questions from both the House and Senate committees reviewing the bills. Also, on September 9, 1975, the Administrator of ERDA sent a letter to Congressmen Magnuson and Teague to further express ERDA's viewpoint. Wholehearted support to the goal of developing non-petroleum options for transportation was expressed, as was acknowledgement of the desirability for demonstration and the many advantages that would result from the use of electric or other stored energy vehicles. The primary purpose of the letter was to express the only reservation that, in proceeding too rapidly toward demonstration with current technology, the goal that Congress and ERDA both seek might not be achieved.

On October 7 and 10, 1975, similar hearings were held by the Senate Commerce Committee on S. 1632 and H.R. 8800. ERDA testimony was presented by Mr. Austin Heller who agreed with the objectives of the bills but testified against them due primarily to their inflexibility in requiring an early, large demonstration, but also agreed that the bill would be supported if sufficient flexibility for the demonstration was provided. A staff mark-up of S. 1632 was considered by the Senate Commerce Committee in executive session on April 29, and favorably reported on May 4, 1976. The Senate passed the bill on June 14, 1976, 72 to 16.

Senate-House Conference

H.R. 8800 and S. 1632 as passed had significant differences from their predecessor bills, as well as from each other. Both bills were, from ERDA's viewpoint, significantly improved with regard to their demonstration requirements. The House bill, H.R. 8800, required contracting for vehicles for state-of-art evaluation within 12 months of enactment, development of performance standards within 12 months, and contracting for 5,000 vehicles within 42 months. On the other hand, the Senate version required development of a state-of-art report within 12 months of enactment, promulgation of performance standards within 18 months, contracting for 2,500 vehicles within 24 months, revision of performance standards within 54 months, and contracting for 5,000 vehicles within 60 months. In addition, the Senate bill gave great flexibility to the Administrator to determine the number of vehicles to be procured and some flexibility in the timing of the buys. House-Senate Conference was held during the week of July 18 and the bill was reported out on July 22, 1976. The conference substitute set forth a demonstration program which generally incorporates the certain schedule and vehicle quantities contained in the House bill, but with the increased flexibility of the Senate amendment in terms of a lengthened schedule and provision for data and number changes in the event of specified determinations.

Passage of the legislation

The bill as reported out from Conference passed the House on August 31, with a vote of 344 to 39, and passed the Senate on August 26, with a unanimous voice vote. The President vetoed the bill on September 13. This veto was overridden in the House on September 16 with a vote of 307 to 101, and in the Senate on September 17 with a vote of 53 to 20.

Last ERDA position on the legislation

On September 3, 1976, a letter signed for the Administrator of ERDA was sent to Mr. Frey of the White House staff to express ERDA's opinion for the then pending Presidential action on the Electric and Hybrid Vehicle RD&D Act of 1976. In view of the fact that Congress had responded to ERDA's expressed concern about the timeliness and magnitude of the demonstration program, ERDA moderately restated its concern over the resulting schedule with recommended signature of the bill in recognition of the contribution electric vehicles can make in reducing dependence on foreign petroleum supplies.

III. ELECTRIC VEHICLE INDUSTRY CHARACTERIZATION

In order to ascertain the impact Public Law 94–413 may have on growth of the fledging domestic electric vehicle industry, it is appropriate to review the historical record of the industry and to briefly depict its present economic and technological stature as influenced by entrepreneurial and government agency interests.

Electric vehicles once occupied a major role in the personal transportation in the United States. In the early part of the Twentieth Century, electrics substantially outnumbered heat engine powered vehicles. One-third of the vehicles in New York City, Boston and Chicago in 1904 were electric. Large electric truck fleets were operating by 1915. Range, weight and controller reliability were their major drawbacks. The development of the self-starter for the internal combustion engine and the ready availability of cheap fuel (gasoline at 10¢/gallon) coupled with the public's desire to escape the range limitations of the early electronics, lead to the electric vehicle's demise for most practical purposes by the 1920's.

The search for means to curtail air pollution caused a rebirth of interest in the late 1960's, but remained for the oil embargo of 1973 to dramatize the positive role the electric vehicle might play in the Nation's future transportation system. With petroleum resources assuming major economic and political importance, it was recognized that use of electrics could create a shift in our transportation energy base to less critical resources by relying on coal, nuclear or hydroelectric powered electric generating plants to supply energy for vehicle propulsion.

The present nature of the international electric vehicle industry today is presented in two parts: (1) as it exists in the United States and (2) as it is abroad. As the subsequent discussion unfolds, it will be seen that the domestic industry is characterized by small entrepreneurial manufacturers who independently seek to build and market a saleable product, whereas foreign work is conducted by primary industries that emphasize integrated research and engineering development of electric propulsion systems along with a planning program for the infrastructure needed to support commercial applications of such systems. Many foreign programs are also co-sponsored by government agencies.

Prior to Public Law 94–413, the domestic electric vehicle industry as a whole had not had government support and, with the exception of battery research, there has not been significant research and development work sponsored by the government. Hence, the industry can be viewed as consisting of firms with small production volume capabilities and with small engineering staffs that are limited in their ability to address the long-term durability, reliability, and safety needs for vehicles now on the market. Suppliers of components are providing only limited support in terms of specialized designs and technology development because of the small volume demand for the new products. The U.S. manufacturer then becomes an assembler of available components rather than designers of integrated propulsion and vehicle systems possessing unique characteristics for the intended application. These small manufacturers have difficulty in developing the necessary vehicle support and commercial infrastructure such as spare parts suppliers, repair stations, battery service facilities and trained maintenance personnel to assure a successful widespread public reaction to electric vehicles.

The major U.S. automotive companies support electric vehicle-related research and development work but none appears to be pursuing a marketable vehicle as are their foreign counterparts. Testimony presented to Congress indicates that the U.S. automotive manufacturers have not found a sufficiently large market for electric vehicles to justify heavy corporate research and development expenditures at the present time.

While the major automotive firms are reluctant at this time to enter the electric vehicle market, this decision has not kept numerous small manufacturers from seeking a viable market for their product. An example of this effort is the manufacture for public purchase of over 2,000 two-passenger Citicars to date by the Sebring-Vanguard Corporation. Of this number 1,300 were produced last year and constituted the largest worldwide electric vehicle production figure for that period. Next in size was the manufacture of 350 DJ5E electric jeeps by AM General Corporation and Gould, Inc. for sale to the U.S. Postal Service. Sales from all other manufacturers are estimated to have totalled less than 50 vehicles in the United States.

Unfortunately, the lack of a sustained market has brought many of these firms to the brink of economic failure. The prospects for implementation of Public Law 94–413 should serve to preserve hope for the industry that technological and economic aid can reverse the present situation and infuse a renewed vitality that may create a growing, viable marketplace for electric and hybrid vehicles.

The most significant developments in electric-vehicle programs today are to be found abroad. Major projects are currently under way around the world in Germany, France, Britain, Japan, Italy, Sweden, and several East-European countries (including the USSR). Significant efforts are also being conducted in the Republic of China and Taiwan.

The largest of these programs (notably those in Germany, Japan, France and England) share a number of common features. The first prominent characteristic has been the highly visible participation of the automotive manufacturers. These include Volkswagen and Daimler-Benz in Germany, Renault in France, Fiat in Italy, Saab in Sweden, and Toyota, Nissan, Daihatsu, and Toyo Kogyo (Mazda) in Japan. Secondly, these firms are working in concert with prominent equipment manufacturers of batteries, motors, controllers, etc.

Thirdly, in some cases, they have combined programs with vehicle users and/or electrical utilities as well.

In the U.K., for example, Joseph Lucas Ltd., the nation's largest electrical component manufacturer, and Chloride, the world's largest battery company, have active programs under way. These companies have been working with the U.K. postal service and industrial freight movers on the user requirements. Also, GM (U.K.) and Chrysler (U.K.) are participating with them.

In Germany, RWE, the country's largest utility, created a separate company called GES to advance electric transport in the late 1950's. Today, GES heads a consortium of major industrial organizations including VW, Daimler-Benz, M.A.N., Bosch, Siemens and Varta which has spent $40 million of its collective private R&D funds in recent years. A new company, SELAK, is being formed to advance electricity supply for electric vehicles.

Foreign government support of R&D and demonstration projects is found to be on the increase. The Japanese Government invested $17 million in battery and vehicle R&D during the period from 1971–1975, while in Germany $12 million has been spent for battery research and a bus demonstration project since 1974. In England, advanced battery research is supported by British Railways, the Electricity Council, and the effort is coordinated nationally by the Atomic Energy Establishment laboratory at Harwell. The extent of government support in the USSR is not known, but the program appears vigorous with a number of demonstration vehicles built to date.

While prototype passenger cars have been built, the major foreign efforts are presently focused on commercial vehicles, notably delivery vans, light trucks and buses since these are seen as the most likely early market for electric vehicles. In addition, this work shows a strong emphasis on support systems and infrastructure not seen as yet in this country.

In England, small scale manufacturing of commercial vehicles continues where an estimated 60,000 commercial electric vehicles of various kinds are in daily service. Bolstering this trend is the recent report that Vauxhall, a division of General Motors, will begin building and marketing a Lucas-designed van.

In the worldwide market, hybrid vehicles are still in the experimental state and are not as yet offered for sale. Heat engine-electric hybrids have been built by a small number of organizations, notably Volkswagen in Germany and Petro-Electric Motors, Gould and the University of Florida in the United States. These generally are regarded as proof-of-principle vehicles rather than preproduction prototypes. Thus, there is presently no industrial base dedicated to the manufacture of hybrid vehicles; but, one can expect that those companies working on pure electrics would have the capability to produce hybrids as well. This aspect of industry status does raise the question of whether or not a significant number of suitable hybrid vehicles would be available for the first stage of the demonstration projects.

The term "industrial base" can be used in discussing the domestic electric vehicle industry. If one thinks in relative terms of the structure and techno-economic depth of the automotive industry, there is presently no evidence of an assured electric and hybrid vehicle industrial base. For example, production capacity for electrics can be measured in millions of dollars, compared with billions of dollars for the current internal combustion engine-based automotive industry. It is more appropriate to describe the present electric and hybrid vehicle industry size as an "R&D base" rather than a manufacturing base. In any case, the base which presently exists in the United States lacks the depth of government and industrial support found in other countries. As a result, the vehicles presently marketed could prove unsatisfactory in many user environments, and thereby, generate an unsatisfactory reaction in the minds of the public. This would likely result in a slackening in development of the new propulsion technology and infrastructure needed for assuring the growth and continuity of broad user acceptance. Thus it appears that P.L. 94–413 will, and must, provide an important, much needed, stimulus to the American electric vehicle industry.

IV. PETROLEUM SAVINGS AND TECHNOLOGY REQUIREMENTS

From a national perspective, electric and hybrid vehicles are attractive options for providing future highway transportation services. The introduction of vehicles of this type will make a significant contribution toward reducing the reliance of the transportation sector on crude oil and the dependency of the United States on oil imports from foreign sources.

There are potential markets for electric and hybrid vehicles in both private and commercial applications such as passenger vehicles, delivery vans, agricultural vehicles and light duty trucks, particularly in the longer term. Within the time frame encompassed by the Electric and Hybrid Vehicle Research, Development and technology can be made. This technology will provide electric vehicles with extended daily urban operating ranges of 100 miles or more. As a minimum, this range capability could substantially impact the buying trends of second and third car households. At present, the number of vehicles owned as second and third cars is 26 million. This substitution alone would result in a savings of about 400 million barrels of oil annually by the year 2000. In addition, the Technology advances which will be generated by activity under Public Law 94–413, coupled with improved urban planning and public transit, will allow the early adoption of electric vehicle by many single car households.

Hybrid vehicles offer an important set of options for meeting personal transportation needs. They may be operated in an all-electric mode for short-distance urban trips, thereby obtaining the energy advantages of the electric vehicle. Alternatively, they may operate in the hybrid mode with unrestricted range, at a higher efficiency than conventional vehicles. The major technological challenge to the industry will be to produce these benefits within an acceptable cost framework. As technology and demonstration programs reduce the barriers to implementation, additional substitution of electric and hybrid vehicles into this transportation sector could occur in commercial application.

In addition to its potential for making significant inroads in shifting the transportation energy base away from crude oil, the penetration of electric and hybrid vehicles into the transportation sector offers the following additional benefits:

TABLE 1.—POTENTIAL ELECTRIC VEHICLE BATTERIES

Batteries			Current (October 1975)				Projected			
Systems	Electrolytes	Temp.°C	W-hr/ kg	W/kg (peak)	Cycle life	Cost per kWh	W-hr/ kg	W/hr/ kg	Cycle life	Cost per kWh
Near-term (1-2 yr)										
Lead/acid (SOA)	Aq. H_2SO_4	*RA	30	50	700	$50	50	150	>1,000	$50
Ni/Fe	Aq. KOH	RA	44	130	1,500	120	60	150	>1,000	120
Intermediate term (3-5 yr)										60
Lead/acid (advanced).	Aq. H_2SO_4	RA					50	150	>1,000	
Ni/Zn	Aq. KOH	RA	70	110	200	800	90	150	>1,000	50
Long-term (5 yr)										
(Zn,Fe)/air	Aq. KOH	RA	80-120	40	150	2,000	90	80	>1,000	60
Zn/Cl_2	Aq. $ZnCl_2$	RA	66	60	100	2,000	130	150	>1,000	50
Li/MS	LiCl-KC1 eutectic	400-450	100	120	250	2,000	150	300	>1,000	40
Na/S	B-alumina	300-350	90	100	200	2,000	170	200	>1,000	40

*Room ambient.

TABLE 2.—TRANSPORTATION FLYWHEEL TECHNOLOGY AND PROJECTIONS

Element	Current 1976	Near term 1980	Far term 1985
Isotropic material rotor energy density (watthour per pound)	3-14		5-15
Composite-rotor energy density (watthour per pound)	[1] 10-20	30-40	60-70
Ball spin bearings:			
Life (years)	3-5		3-5
Losses (percent of rated power)	2-4		1-2
Hybrid bearings:			
Life (years)			5-7
Losses (percent of rated power)			1-2
Motor/generator efficiency, percent	60-94		88-97
Overall efficiency, percent	55-70	70-75	75-80

[1] Laboratory/demonstrations.

(1) By using energy provided by central power plants, the electric vehicle offers a potential efficiency improvement compared to conventionally powered vehicles.

(2) Hybrid vehicles are projected to provide a 20% improvement in vehicle efficiency compared to conventional, heat engine-powered vehicles.

(3) Electric vehicles can make use of existing utility capacity for recharging during off-peak hours. Currently, 40-50% of utility capacity is idle at night, an amount capable of recharging up to 35 million vehicles without additional capital investment.

(4) The Nation would gain the ability to limit and/or control the pollution emitted from the transportation sector more effectively. The primary pollution source would be the central station power plant, which is more readily controlled than multiple, mobile vehicle pollution sources.

The benefits of the implementation of hybrid and electric vehicles cited above assume that these vehicles are able to enter the consumer market. A significant advance in electric and hybrid vehicle technology must be made before this penetration can take place. Many important factors such as reliablility, range, cost (both initial and life cycle), availability, and public acceptance must be improved for these vehicle options to become viable to the consumer. Technology development as proposed under the provisions of the Electric and Hybrid Vehicle Act can play a fundamental role in providing acceptable electric and hybrid vehicle options for consumer markets. The areas of required technology emphasis and their impact may be briefly summarized as follows:

(1) *Battery.*—This technology is essential to the attainment of acceptable range, reliability and charging characteristics, and low initial and life cycle cost.

(2) *Propulsion system* (battery, motor, controller, etc.)—Research and technology development in this area will increase system efficiency and reduce cost. Measurements on existing propulsion system efficiencies indicate that the potential exists for doubling vehicle range through propulsion system improvements alone.

(3) *Manufacturing processess.*—More efficient process involving critical materials use and component fabrication must be developed to reduce system cost.

Overcoming the technical barriers of electric and hybrid vehicles achieves only a portion of the overall job of convincing the consumer, both private and commercial, that these vehicles are an acceptable alternative to conventional systems. An aggressive demonstration program will supply much of the additional education and experience necessary. The demonstration program as set forth in Public Law 94–413 will:

(1) Stimulate active research and development in both government and private sectors.

(2) Provide public education of the advantages and potential of electric and hybrid vehicles.

(3) Develop an operation data base on vehicles in various applications, both private and commercial.

(4) Provide market research data on vehicle acceptabliity and use patterns.

(5) Identify support and service industry requirements for electric and hybrid vehicles.

(6) Provide insights into manufacturing techniques for these vehicles.

(7) Stimulate the development of a limited production capability for these vehicles.

(8) Provide insight into various regulatory incentives that would make these vehicles more attractive.

Thus, the process of providing electric and hybrid vehicle options for the future that have a reasonable probability of being accepted in the marketplace requires a combined effort, including advances in technology, a demonstration program to develop manufacturing and operating experience, and an information demonstration program to educate both the consumer and the technical community to their advantages and potential.

V. ENERGY STORAGE SYSTEMS TECHNOLOGY

The ERDA energy storage systems research and development program relates to the electric transportation vehicle in the electrochemical, mechanical, chemical, and thermal sectors.

The electrochemical program is concerned with battery development. At present, the base battery research and development program covers both bulk storage (utilities) and transportation systems.

The mechanical program is investigating flywheels for use with electric and hybrid vehicles. The chemical program is looking at hydrogen as a fuel and the thermal program is aimed at thermal storage for use with a stirling engine. The work is being conducted by industry, ERDA national labs and other government agencies under contract to ERDA. In addition, there is a significant independently industry funded program. One major area of activity in the ERDA energy storage systems effort is the development of batteries for electric and hybrid vehicle uses. R&D is being conducted on seven battery concepts for the electric vehicle program, as shown in Table 1. These may be categorized principally into near-term and advanced batteries. Three batteries are being emphasized for near-term use: lead/acid, nickel/zinc, and nickel/iron. There are ten ERDA sponsored contracts with industry working on these three battery systems.

It is anticipated that the lead/acid, Ni/Zn and Ni/Fe batteries perhaps would be available for the first electric vehicle program demonstration vehicles. All three would be available for the second demonstration. The advanced batteries (zinc/chlorine, sodium/sulphur, lithium/metal sulfide, and metal/air) are farther down the road; however, some of these battery systems would be available for the second electric vehicle demonstration phase.

Table 1 shows the characteristics and the relative goals of batteries in the program and the time frame in which these goals are expected to be achieved. The specific energy (w-hr/kg) shown in Table 1 is a measure of the range which these batteries would provide for the electric vehicle. The relative range values for a four passenger vehicle operated at 40 mph constant velocity when utilizing the listed battery systems are as follows:

RELATIVE RANGE—MILES

	1978	1980	1981
Pb-acid-lead/acid	60	80	
Ni/Fe-nickel/iron	70	90	
Ni/Zn-nickel/zinc	80	110	
Zn/Cl2-zinc/chlorine	90		140
Li/MS-lithium/metal sulfide	110		180
Na/S-sodium/sulphur		150	180
Fe, Zn/air-metal air	70		110

It is anticipated that the electromechanical base battery program will continue to be active throughout the duration of the Electric and Hybrid Vehicle Act. This program will support R&D on electrochemistry related to batteries, the utility battery program, and the basic energy storage work related to the Electric Vehicle program.

The current flywheel R&D program is investigating the use of flywheels with electric or hybrid vehicles. A battery/flywheel propulsion system is presently under development for installation in a U.S. Postal Service electric vehicle. The addition of the flywheel is expected to improve the performance over existing postal service battery vehicles. Table 2 shows the technology status and projections for transportation flywheels. This R&D program must be expanded as a result of the Electric and Hybrid Vehicle Act.

While near-term batteries and flywheels clearly offer the greatest potential for meeting the requirements of the Electric and Hybrid Vehicle Act, other subsystems now under development, will continue to be considered as possibilities for the future. These include thermal and hydrogen storage systems.

VI. METHODOLOGY FOR TECHNOLOGY TRANSFER

A major objective of the Electric and Hybrid Vehicle Research, and Development and Demonstration Act is to promulgate an available technological base for the production and use of practical electric vehicles with improved performance and economy of operation. The information base involved encompasses design, manufacturing, economic, operating, environmental, and other data required to guide the development, growth and improved market penetration of the electric car industry. A systematic, orderly plan to transfer this technology to private enterprise is required to most effectively introduce advances in electric propulsion into public use. This appendix provides a brief description of the elements of the technology transfer process to be implemented.

Target audiences

The target audiences for the data base transfer include:

(1) Potential industrial manufacturers and/or suppliers of vehicles, vehicle components, and vehicle operating support equipment and facilities.

These manufacturers comprise an interrelated and interdependent community and can largely be viewed as a single audience. Included in this group is the electric utility industry which must be kept abreast of projected battery recharge energy demand growth rates and load characteristics for the proper planning, siting and fuel transportation requirements of new, increased capacity electric power generating stations required to support the growth of electric car population. Potential manufacturers include present major and minor automotive manufacturers, present electric vehicle manufacturers, and new manufacturers.

(2) Potential users:

(a) Federal Government departments, agencies, and offices (e.g., GSA, Post Office).

Federal Government entities are large volume buyers and users of automotive vehicles, and are in an excellent position to demonstrate the practicality of electric vehicles by mandating their purchases and use for Government operations.

(b) Fleet operators in the private sector (e.g., urban delivery, taxi service.).

(c) Personal transportation users.

(3) Energy and environment conservationist organizations.

Information base

Specific areas of information which can be made available to the audience, described above, include the following:

(1) Manufacturers and suppliers: (a) Access to the ERDA reference and test vehicles for inspection and measurements; (b) Intermediate level fabrication and assembly drawings; (c) Operator's manual,

including servicing instructions and brochures on catalog items; (d) Final specifications; (e) Test reports; and (f) Consulting services.

Additional technical support options that could be made available to manufacturers include (1) providing components or chassis (including battery, drive train and controls) or other subassemblies for possible vertical integration into the manufacturer's design, and (2) subassembly drawings and trade-off information as a basis for design improvement and optimization. In addition a limited number of reference vehicles could be made available to small businesses for test and evaluation.

(2) Potential users; (a) Operating instructions; (b) Maintenance requirements; (c) Repair manuals; (d) Performance specifications; and (e) Use limitations.

This information will serve to enhance and promote the acceptance of electric vehicles by providing to the users of demonstration vehicles the proper preparation and guidance with regard to the system performance and operating characteristics to be expected.

(3) Energy and environment conservationists: (a) Vehicle performance characteristics; (b) Energy consumption characteristics; (c) Fuel economy (hybrid systems); (d) Pollutant emissions; (e) Emission control effectivity; and (f) Air quality effects, projections, and comparisons with conventional vehicles.

Transfer methodology

The following techniques and devices will be employed in executing the methodology transfer:

(1) Potential industrial manufacturers and/or suppliers:

(a) Participation in the program through contracts, grants, joint agreements, etc., under which potential manufacturers will be actively involved in the development and test of vehicles.

(b) Prompt and regular distribution of technical reports describing projects and progress under the programs.

(c) Invitations to periodic tests and demonstrations.

(d) Invitations to periodic technical conferences and seminars.

(e) Open invitation to technical consultation.

(f) Articles in technical and trade journals and other periodicals.

(g) Presentations to technical and trade associations.

(h) Exhibits at industrial conventions and trade shows.

(i) Prompt professional response to all inquiries and indications of interest.

(2) Potential users: (a) Press releases/press stories/press conferences; (b) Direct mailings (brochures, announcements, articles); (c) Invitations to periodic tests and demonstrations; (d) Demonstrations at major public expositions; (e) Invitations to potential users conferences and seminars; (f) Open invitation to technical consultation; (g) Registers of manufacturers; (h) Prompt professional response to all inquiries and groups; and (i) Video/film clips, motion picture films.

(3) Energy and environment conservationists: (a) Press release/press stories/article; (b) Public demonstrations, as appropriate; (c) Presentation to appropriate groups; (d) Video/film clips, motion picture films; and (e) Response to inquiries and expressions of interest.

Implementation

The foregoing constitutes a basic approach. Obviously, as the program goes forward, potential manufacturers and potential users will be

more specifically identified, and effective methodolgy will be more
precisely defined. Potential manufacturers will be attracted to situa-
ions that are profitable in their context. Potential users will be
ttracted to problem solutions that are practical in their context. The
nethodology employed must be sensitive to the attitudes of both and
esponsive to those attitudes.

VII. FINANCIAL INCENTIVES

In addition to the market support provided to the emerging elec-
ric and hybrid vehicle industry through the demonstration buys
f up to 7,500 vehicles, Public Law 94–413 authorized two spec-
fic forms of financial incentives and directs certain studies related in
art to these incentives.

The two specific incentives are covered by Section 9, Encouragement
nd Protection of Small Business and Section 10, Loan Guarantees.
urther, Section 13(c) authorizes studies and research on incentives to
romote broader utilization and consumer acceptance of electric and
ybrid vehicles technology.

The following review of these incentive areas will: (1) outline the
rovisicns of Public Law 94–413, (2) suggest options ERDA may
xercise in scoping and carrying out the financial incentives, and (3)
oint out the impact of the schedule, funding and other provisions of
ublic Law 94–413 on the implementation of these incentives.

mall business assistance

Before proceeding it should be noted that pursuant to Section 3 (8)
f Public Law 94–913 the standards for qualification as a small business
the electric and hybrid vehicle industry are to be prescribed by the
dministrator of ERDA after consultation with the Small Business
dministration. Contacts have been made with the Small Business
dministration by the ERDA Small Business Advisor and it has been
stablished that a small business concern under Public Law 94–413
ill be a concern which satisfies the criteria of 13 CFR 121.33. Section
of Public Law 94–413 authorizes the following actions in support of
mall business concerns:

(1) Reserve a reasonable portion of funds for research, develop-
ent or demonstration for contracts with small business concerns.

(2) Include in all contracts the terms, conditions, and payment
chedules as may assist in meeting the needs of small business and
void terms, conditions or penalties that would tend to prevent their
articipation.

(3) Make planning grants available to qualified small business
oncerns which require assistance in developing, submitting, and
ntering into such contracts.

mall business funding reserve

The Director of the Division of Procurement has been requested to
ssist the Division of Transportation Energy Conservation in prepar-
ng recommendations for establishing the level of funds that could be
ffectively utilized by small business concerns. Factors to be considered
this assessment include the industry product profile, the mix of
rojects to be funded in R&D demonstration and study areas, and
arget levels for small business participation in ERDA-wide and
onservation-specific programs.

Procurement regulations for small business

In order to enable the otherwise desirable participation of smal business concerns, all procurement processes will be reviewed to determine if there are terms, conditions, procedures or timing which negatively impact on the small business concern. The Director of the Division of Procurement has been requested to assest the Division o Transportation Energy Conservation to identify restrictive procurement practices and, if so identified, to instruct the procurement system to avoid such practices and to develop recommendations concerning revisions to any restrictive procurement regulations.

Small business planning grants

The Administrator has very broad latitude, under Public Law 94–413 in determining the scope and extent of the planning grant activity. The statute instructs that such grants be made available for "developing submitting and entering into . . . research, development or demonstration contracts".

The Director of the Division of Procurement has been requested to participate with the Office of the General Counsel and the Division of Transportation Energy Conservation in developing recommendations for planning grant procedures.

The statute does not set a limit on the size of each grant nor a cumulative total for the program. It does not specify if these grant are to be awarded continuously, once per year or at other intervals It does not tie the grants to the preparation of competitively solicited proposals, nor does it designate the exclusion or inclusion of unsolicited proposals. An initial review indicates that such grants are intended to assist small business with bid and proposal expense, and are no intended for preparation of other reports which are end products At this time it appears that the scope of the planning grant activitie should be limited to the initial four years of the EHVP.

Timing elements are considered very significant in developing regulations and assuring their subsequent impact on procuremen lead times. If a separate planning grant award is to be made prio to each request for proposal procurement lead times would be extended intolerably. It is therefore appropriate to propose recommending quarterly award of such grants to the most qualified participant up to a total budgeted ceiling for the quarter with a commensurat limit for each grant.

Loan guarantees

Section 10 of Public Law 94–413 sets forth in some detail the scop and content of the loan guarantee authorities leaving only a limite area for discretionary action by ERDA in the implementation of th program. A brief outline of the significant provisions of Section 1 follows:

Section 10, loan guarantees

(1) . . . available to qualified small business and other qualifie borrowers. . . .

(2) . . . to encourage commercial production . . . guarantee principal and interest of loans for: (a) Research and development, (b Prototype development of vehicles and parts, (c) Construction relate to research, development and production, and (d) Initial operatin expenses of development and production.

(3) Up to 90 percent of cost of activity of loan.

(4) To be guaranteed only if: (a) The Administrator determines he interest rate is reasonable. (b) Term does not exceed 15 years. c) The amount of the loan enables the borrower to carry out the ctivity. (d) There is a reasonable assurance of repayment. (e) There s no other reasonable means of financing available.

(5) (a) Each loan guarantee not to exceed $3,000,000 unless raised y Administrator to meet purposes of the Act and Congress is notified, nd (b) Aggregate guarantee not to exceed $60,000,000.

(6) Qualified borrower must have presented satisfactory evidence f interest in EHVP and is capable of research or completing and evelopment and production of vehicles or components.

(7) ERDA pays lender interest charges if: (a) Borrower is unable to neet charges and cost of government is less than cost of default; b) Charges are no greater than interest charges to borrower; and c) Upon default the Attorney General shall recover from such assets f the defaulting borrower as are associated with the activity or from ther surety included in terms of guarantee.

(8) The loan guarantee authority expires five years from enactnent of P.L. 94–413 (September 17, 1981).

(9) Applicant must be U.S. citizen or National.

In planning the implementation of the loan guarantee program, ertain discretionary areas must receive close consideration. The most ignificant is Section (4) under which criteria for acceptance of an pplication for loan guarantee will determine the overall effectiveness f the program. Care must be taken not to exclude those organizations vhich could be assisted in becoming a healthy participant in the comnercial electric vehicle industry. On the other hand, the criteria should e scoped to permit adequate screening of applicants and to thereby dentify those who see the federal funds as an opportunity to cut heir risk in promoting a small, short term, venture for the purpose of he demonstration buys. Specific decisions involved the rate for inerest, the degree of appropriate experience and history of involvement n the electric and hybrid vehicle or associated technologies, the size of he applicant's indebtedness related to other activities, and the elationship to the product of service planning under the loan. Many ther factors are also applicable.

Experience in other federal loan guarantee programs can provide uidance to ERDA in implementing the loan program designated by ublic Law 94–413. Because of time constraints imposed by the nabling legislation, it is important that the application and approval rocess proceed smoothly and that administrative controls and uarantee fees not inhibit applications. The statute gives the Adminisrator flexibility in development of procedures and controls.

Furthermore, it is clear that the EVHP loan guarantee program is ot a high-volume, risk-spreading program like FHA and VHA ousing guarantees where the Government as a matter of social policy vants to ensure availability of credit to classes that might otherwise e shut out of loan markets. Such programs are generally of long duraion, and fairly reliable experience factors as to probable costs (deaults) can be developed EHVP, on the other hand, involves "acelerated" research and relatively short lead times for vehicle roduction after performance standards have been issued. Accordingly, he focus is on individual firms, and the project must identify those who are both genuinely interested and capable (i.e., those who are "qualified borrowers").

Additionally, EHVP will not involve the guarantee of extremely large investments such as those required for commercialization of synthetic fuels, and individual project ceilings are lower and payback periods are shorter than for geothermal guarantees. Guaranteed loans, therefore, are likely, in many cases, to be handled as an adjunct to a company's normal business operations and involve financial institutions familiar with the applicant's capabilities and needs. This situation will facilitate assessment of prospective borrowers and the processing of applications.

Funding for the loan guarantee program should be frontend loaded. In order to attract the commercial loan in today's tight money market, it is virtually mandatory to display a capability to meet potential defaults from the initiation of the program. Each loan guarantee has a ceiling of $3 million with an aggregate limiting ceiling of $60 million for the program as specified in the Act. Loan Guarantee acceptance criteria should be established with sufficient flexibility to provide a reasonable incentive for the serious entrepreneur to expand or develop an existing capability and to obtain commercial money while at the same time those criteria must be restrictive enough to protect the program from the rush of irresponsible participants.

Incentive studies

Section 13(c) of Public Law 94–413 authorized studies and research on incentives to promote broader utilization and consumer acceptance of electric and hybrid vehicle technologies and directs that a report on such activities be submitted to Congress annually.

Certain studies may be undertaken independent of other activities in the demonstration or research programs. These studies should be initiated early in the EHVP and have an effect on subsequent portions of the program, particularly the framing of the second or advanced technology demonstration.

Examples of the areas of studies that may be examined are:

(1) Sales and use pattern where electric vehicles have been marketed.

(2) Reasonable targets of the electric and hybrid vehicle share of the future automotive market.

(3) Identification of constraining factors that could prevent achievement of such targets.

(4) Review of existing financial incentives that promote or retard market growth.

(5) Determination of means for subjugating market growth barriers by adequate assistance and identification of barriers most susceptible to financial impact.

Studies in other areas will depend on data to be gathered as a result of the baseline and state-of-the-art evaluation testing and first demonstration program. These study efforts may be contracted for separately or planned as a part of the demonstration program. They will be long range studies directed toward guiding the emergence of a commercial electric and hybrid vehicle industry, but could likely affect the planning for the second vehicle demonstration program.

Examples of such study areas are:

(1) Customer financing patterns and vehicle manufacturer and disdistributor financing.

(2) Electric and hybrid vehicle use relative to other available transportation means.

(3) Lifetime costs as a function of vehicle depreciation period, etc.

(4) The impact of specific financial incentives or special assistance based on demonstration program results.

VIII. VEHICLE DEMONSTRATION PROGRAM

Public Law 94–413 authorizes the administrator of ERDA to conduct demonstration projects to determine the economic and technological practicality of electric and hybrid vehicles for personal and commercial use in urban areas and for agricultural and personal use in rural areas. The administrator further must ascertain among other factors, consumer needs and desires, and the required changes in road design, urban planning, traffic management, maintenance facilities and regulatory policies that will be required to facilitate the manufacture and use of electric and hybrid vehicles.

Objectives

ERDA is faced with the necessity of establishing an overall approach toward the vehicle demonstration project which will maximize the value of the demonstration while minimizing the risk of obtaining inaccurate results or an unfavorable public reaction stemming from factors other than the characteristics of the vehicles. Some of the desired outputs from the project are:

(1) Identification of suitable roles for electric and hybrid vehicles in the nation's transportation system, including geographic and climatic and commercial situations which encourage or limit their use.

(2) Development of consumer awareness of the characteristics of electric and hybrid vehicles.

(3) Establishment of an operating cost, performance, and reliability data base for in-service operation.

(4) Provision of inputs for planning and direction of later phases of the Base R&D program.

(5) Development of insights into maintenance, service and support requirements.

(6) Development of a data base which will allow more precise impact and market assessments.

(7) Stimulation of industry capability for production of quality vehicles.

A viable transportation option requires acceptance by the public, which means that the demonstration project must be designed with the ultimate private and commercial user in mind. Experience shows that the evaluation of public reaction to a new product is not a simple matter and requires a highly specialized communication effort. To structure the data acquisition process and to insure an adequately organized project that includes such a diversity of factors requires a comprehensive project plan. Only by adopting a "user orientation" toward the project can ERDA expect to obtain an accurate assessment of electric and hybrid vehicles. The selection of test sites, screening and selection of participants (users), definition of support requirements, data evaluation, and communication of project information to the public and all of this within a framework which as closely as possible resembles the commercial world is essential for achievement of specified goals.

Specifically, Public Law 94–413, Section 7, Demonstrations, authorizes the following actions:

Schedule:	*Action*
Within 12 months	Characterize current state of the art through vehicle tests.
Within 15 months	Promulgate performance standards for both personal and commercial use; report to Congress.
Within 21 months	Contract for phase I demonstration purchase/ lease of 2,500 vehicles.
Within 39 months	Deliver last of 2,500 vehicles; conduct demonstration.
Within 48 months	Amend performance standards.
Within 54 months	Contract for phase II demonstration purchase/ lease of 5,000 vehicles.
Within 72 months	Deliver last of 5,000 vehicles; conduct demonstration.

The above demonstration program will be conducted in consonance with and supported by the research and development authorized by P.L. 94–413, as well as by a portion of the Base R&D program on electric vehicles.

Implementation plan

The primary organizational components of the demonstration as currently envisioned are: (1) a demonstration plan/management support contract; (2) demonstration site operating contractor o contractors; (3) vehicle manufacturer/supplier; and (4) certain industrial, commercial, or Government fleet operators and individuals who may become vehicle users.

Implementation of the demonstration project will be largely conducted by contractors chosen from among those industries ultimately responsible for the commercial success of electric and/o hybrid vehicles, leaving the Government with a minimal role o overseeing operations and verifying that schedules are adhered t and goals achieved.

The first responsibility to be recognized is the need for initia planning and design of the organization for the demonstration. Ther are almost an infinite number of variables to be considered in decisions such as: where the demonstration is to be conducted; how many vehicles per site; what type of vehicles per site; who operates the sit data collection system; who is to use the demonstration vehicle an in what mission; what are the legal and financial arrangements between the site operator, user, manufacturer and the Government how vehicle disposal will be accomplished; what is the test dat requirements; how, when, and by whom is test data gathered; ho shall the R&D program interface with the demonstration project and how are both conveyed to the industry and the public.

It is intended to obtain the services of a demonstration planning management contractor by competitive selection to provide plannin support for all activities required to conduct the demonstration an to provide management support to monitor the progress of the demonstration activities. It is anticipated that the purpose of electric vehicl technology improvements will dictate that the two phases of th demonstration will be structured quite differently. The first phase comprised of 2,500 state-of-the-art vehicles, may be limited in th allowable use missions and public exposure in order to minimize any negative impact on consumer acceptance by electric or hybrid vehicle performance that is not comparable to internal combustion engine-powered vehicle performance.

The results of the planning and organization design effort for the demonstration project will be a description of the planning, procedures, interfaces, and infrastructure in sufficient detail to specify the scope work for demonstration site operators bidding to conduct the Phase I and/or Phase II demonstrations. In addition, management support will have to be provided during the term of the demonstration to assure the coordinated, efficient, and effective performance of the work by the demonstration site operators.

The plan for the demonstration involves the selection and estabishment of demonstration sites, and vehicle operators, provision of vehicles and their logistic packages, the retrieval and synthesis of test data, vehicle disposal, and other activities as required.

In developing the design and content of the plan for the demonstration, several areas have been identified, others may be developed n the course of the planning activity.

Survey of vehicle demonstration operations

A survey should be conducted of vehicle demonstration operations with specific detail attention to the adequacy of the support infrastructure.

Site location and composition

A rationale should be developed for the national distribution of demonstration site locations and site composition including facilities and personnel:

Examples of factors to be considered may include the following:

(1) Site selection criteria: geographical, topographical, climatological, road and use conditions, electric utility involvement—off-peak power generation requirements, regional distribution, accessibility to manufacturers, and local road or highway department involvement

(2) Facility composition: servicing and diagnostics, managemen and communications, conventional replacement vehicles, towing and shipping, financing and insurance, maintenance personnel training, and user personnel training.

Site operators

The appropriate type of organization(s) to operate the demonstration sites should be determined. The desired capabilities of such organizations, and their optimum span of control could include such factors as:

(1) Type of organization: commercial R&D, auto dealers, fleet sales, lease, non-profit, university, and government.

(2) Organizational capabilities: physical facilities for repair, management's interest in electric and/or hybrid vehicles, experience with public relations and commercial business operations, particular experience in conventional automotive vehicle industry, financial reliability and capabilities, prior experience as fleet or vehicle demonstration operator, laboratory or experimental test expertise beyond service and maintenance.

(3) Mix of Operators: One for each site, one for each region, one fo all sites, combination of above, industrial fleet operators as prime site operators or subsite operators, and Government users as prime sit or subsite operator.

Demonstration vehicle users

A plan should be developed to define the appropriate mix of demonstration user/drivers, the methods for their participation in the demonstration, and the various types of vehicle emissions that will b undertaken. Examples of considerations could include the following

(1) Set standards for driver profiles; psychological and driving competence, interest, age, and use groups to match national mix.

(2) Establish proper mix of drivers for commercial, fleet and privat use.

(3) Develop a method of driver solicitation, screening, and selection

(4) Develop driver indoctrination and motivation training program

(5) Develop legal instrument for use between driver and demonstration operator to assure the maximum demonstration input.

(6) Provide for voluntary participation beyond mandatory demonstration operation period.

(7) Develop the proper mix of vehicle use patterns.

Demonstration data

A methodology should be developed to insure the adequacy and completeness of data provided by the demonstration site operators including the form, frequency, content, data capture technique, standardization, synthesis and reporting requirements. Factors involved may include the following:

(1) Identify the various types of demonstration data required

(2) Identify data interface with technical evaluation and R&D functions.

(3) Establish methods for data capture in all areas, i.e., technical operational, financial, legal, traffic control, institutional, etc., by sit personnel and drivers.

(4) Specify type of instrumentation.

(5) Establish method for data correlation and analysis.

(6) Determine specific requirements for data dissemination.

(7) Define communication interface with vehicle manufacturers supporting infrastructure, commercial interests, and the public.

Demonstration vehicle logistical support package

The complete vehicle logistic support package to be provided t the demonstration site operator should be defined. Factors involve may include the following: (1) Maintenance to be provided by manufacturer, (2) Vehicle inventory, (3) Spare parts inventory, (4) Diagnostic instrumentation on or off the vehicle; supplied by manufacture or demonstration operator, and (5) Method and type of shipment o vehicles and spare parts.

Method of financing

The options for financing the purchase of the demonstration vehicle should be explored. Examples of considerations may include th following:

(1) Total Government ownership supported with hold harmless us agreement involving replacement vehicles, etc.

(2) Government purchases and subsequent resale or lease designed to meet cost of competitive conventional vehicle.

(3) User purchase with Government subsidizing any incremental cost over that for competitive conventional vehicle.

(4) Demonstration site operator/user purchase with a sliding scale of Government subsidy support available to potential users.

(5) Participation of banks and other forms of financial institutions for providing vehicle loans to users.

(6) Availability of normal auto insurance package for accidental damage, fire, theft, third party liability, etc.

(7) A combination of the above.

Public information program

A most important element is the development of an appropriate program to provide the widest dissemination of data from the demonstration, including the pertinent special group audiences, with the objective of establishing consumer acceptance and commercialization of the electric and hybrid vehicles. Elements of this program may include:

(1) Development of guidelines for scope, timing and audiences for appropriate public information program effort to make demonstration data available and thereby enhance public visibility of demonstration project.

(2) Develop a list and point of contact with all pertinent trade and industrial associations, institutes and publications.

Pilot demonstration projects

Concurrent with the above planning activities several potential pilot demonstration opportunities should be identified. Pilot projects may be desirable to test the planning concepts of the demonstration plan prior to the implementation of the full scale demonstrations. Such pilot projects could be integrated if successful into the full scale demonstration and thereafter be the responsibility of a demonstration site operator.

IX. VEHICLE SERVICE AND OTHER INFRASTRUCTURE REQUIREMENTS

The introduction of new products in the marketplace has traditionally been viewed as a high risk venture. This is exemplified in the automotive industry by the often lengthy delay in the introduction of new vehicles or new technologies such as automatic transmissions, electronic controls, and radial tires. The risk is further illustrated by the past failures of some new cars offered by large, traditional manufacturers and by the disappearance of companies offering products with advanced or markedly different technologies. One of the major drawbacks to the introduction of new technology is the mammoth effort required to support the conventional introduction of minor changes in an automotive fleet throughout the nation. Only those major companies with effective nationwide organizations, including dealer networks, service facilities, advertising capabilities, and the availability of spare parts and training programs, have consistently fared well. This holds true for both foreign and domestic companies. The selection of appropriate strategies for marketing, distribution and servicing of a demonstration program is therefore critical.

The rebirth of the electric vehicle brings with it a new and different commercial technology. The vehicle's brevity in operating range combined with its high initial cost impose certain restrictions on its initial distribution to individuals and group users. Some candidate locations and user groups for electric and hybrid vehicle demonstrations are:

(1) Retirement communities and small towns in the sun belt for second cars.

(2) Larger cities for specialized delivery services and commuting cars requiring short distances.

(3) Integral institutions such as universities, national parks, go vernment laboratories and public service corporations for in-plant communications and transportation.

Adequate service and maintenance support must be readily available for all of the above possibilities to install user confidence in this transportation concept by retaining a high level of product reliability and a high level of use during trial periods. The service organization to achieve this will require a well trained staff of maintenance people, service managers and parts facility operators deployed at each location.

A manageable organization that is matched to anticipated workloads is required.

The frequency of service required is usually expected to be higher in the early phases of accelerated introduction of a new product. In the case of the demonstration program, the vehicles may range from well tested vehicles with designs reflecting extensive commercial usage to those with little prior testing or in-service experience. Adequate documentation must be developed and records maintained to determine the extent and cost of service and support during vehicle use.

A promising approach to the servicing and maintenance requirements for an electric vehicle demonstration fleet would be to have vehicle manufacturers responsible for the establishment of service, parts, and maintenance facilities and to have the cost of these provisions included in the purchase price of the vehicle. The initial cost of the vehicle could include a service contract for a predetermined period. Such a requirement would accomplish three things: (1) the vehicle would be designed and constructed with the manufacturer knowing the service and maintenance would be a continual responsibility; (2) potential leasers or purchasers of electric vehicles would be provided an economic incentive to participate in the demonstration program because of the guarantee of parts and service; and (3) continuity would be assured to participation of parts suppliers and supporting service personnel.

Other infrastructure requirements to be addressed in the demonstration and early commercialization include battery recharge networks, pricing of electric energy used in off-peak recharging and road maintenance costs presently supplied by petroleum taxes.

X. SAFETY CONSIDERATIONS AND REQUIREMENTS

Public law 94–413 requires that the Secretary of Transportation conduct a study of current and future applicability of safety standards and regulations to electric and hybrid vehicles. In addition to this report, which is due in one year, rules establishing performance standards for electric and hybrid vehicles are to be promulgated within 15 months. In order to assure a successful program, it is imperative that these standards contain requirements that adequately provide for the safety of the passengers using these vehicles without imposing unnecessary restrictions which could have negative impact upon vehicle range and cost.

The more important considerations that must be carefully addressed before the safety requirements are imposed are: crashworthiness, fire protection, electric shock protection, crash avoidance subsystems, placement of batteries, and containment of dangerous materials (e.g., acid electrolyte).

A few of the key points that relate to these safety considerations will be noted briefly in this section.

Since performance and range of electric vehicles are so sensitive to vehicle weight, there will be a tendency to design for minimum body-chassis weight that could lead to compromises in vehicle safety. This design trend is evidenced in most of the presently available electric vehicles and serious concern about the crashworthiness of present electrics has already been voiced by a number of groups, including the Consumers Union of the United States, Inc.

Weight-conscious design that results in the acceptable crashworthiness is a necessary goal for an effective electric vehicle program. Such techniques are especially evident in many of the foreign cars produced in countries with high fuel costs. Vehicles in this class are produced with essentially the same materials and fabrication procedures as the domestic vehicles. However, the "weight conscious" vehicles reflect more functional space allocation, packaging, and overall structural designs and, consequently, they are very weight-efficient while still being strong enough, structurally, to perform their required mission.

The long-term effect that this approach may have on overall vehicle durability remains to be seen in some vehicles, but in the short-term, at least, no significant functional structural performance degradations are apparent. These vehicles provide more occupant space per pound of curb weight than do vehicles in the "current" technical category. The overall vehicle dimensions and the allocation of space are dictated almost entirely by functional requirements. The extent to which styling considerations are allowed to impact dimensions and space allocation is minimal.

Car accident injury and fatality statistics may be categorized in terms of crash direction (frontal, side, rear and rollover). The majority of fatalities at present occur in the frontal crash mode while the side crash mode produces the highest percentage of injuries. The rollover and rear collision modes account for lesser amounts. However, with the presence of a large weight of batteries (and large number of batteries) in the vehicle, the injury statistics of internal combustion engine powered automobiles may not completely prevail for electric vehicles. For instance, the rollover mode would appear to be less likely but potentially more dangerous in the electric vehicle with the presence of batteries filled with acid electrolyte. Also, accident patterns may be different for electric vehicles because of their unique operating environment. Both new crash frequency and severity guidelines may be needed.

Careful design will be necessary to achieve low body-chassis weight and acceptable crashworthiness. In the standards to be promulgated, criteria are necessary to aid the participant manufacturers in their design and fabrication.

A number of subsystems on an automotive vehicle are designed to assist the driver to avoid crashes. Crash avoidance subsystems can be categorized into: suspension, steering, braking, lighting, and windshield wiping and defrosting.

Since many of the electric vehicles will be built by manufacturers who have not had experience in designing and fabricating these subsystems to a high level of reliability, special care must be taken in specifying accurate standards in this area.

Protection from electric shock is a problem closely related to fire protection and, in regard to both cases, careful design of electrical protection devices must be considered as an essential vehicle safety feature. Vehicle operational factors related to this requirement must be delineated in the standards established for the program.

XI. MAJOR FACTORS INFLUENCING THE DEVELOPMENT OF ELECTRIC AND HYBRID VEHICLE INDUSTRY UPON COMPLETION OF R&D PROGRAM

As further discussed in more detail below, the major factors that will influence the development of a commercial electric vehicle industry include: (1) The market demand for electric vehicles; (2) investment in manufacturing facilities for electric vehicles and components; (3) development of sales/service infrastructure; (4) availability of raw materials; (5) impacts on the petroleum industry; and, (6) modification of existing tax structure to include operation of electric hybrid vehicles on public roads.

The market demand for electric vehicles

The most important factor influencing the development of an electric hybrid vehicle industry will be the extent of the demand for such vehicles. These vehicles will have to compete with conventional fuel consuming, internal combustion, engine-powered vehicles. In a market free of direct government intervention and where petroleum-based fuels remain available, consumer acceptance of electric hybrid vehicles will be based on their initial acquisition price, their life-cycle operating costs, their safety, their reliability, and their performance, relative to that of comparable conventional fuel consuming vehicles. Life cycle costs are principally a function of the acquisition price, the cost of maintenance and the cost of fuel. Drastic shortages of petroleum and/or direct Government intervention in the form of subsidy would enlarge the demand for vehicles not fueled with petroleum products.

Investment in manufacturing facilities for electric vehicles and components

The second major factor that will influence the development of the electric hybrid vehicle industry will be the availability of investment capital to the industry. It will have to be demonstrated that the manufacture of such vehicles is an economically profitable venture.

While the availability of a suitable market will be of primary importance, as mentioned above, there will be other factors that influence the relative risk/profitability of entering into such a venture. These include the level of the state-of-the-art of vehicle development at the end of the program, the level of detail of technical know-how available to potential manufacturers in terms of both vehicle design technology and manufacturing production technology, and other factors which influence the technological risk of entering such a venture.

Financial risks will depend on the general availability and costs of capital, as well as the availability and nature of potential Government subsidies which would take the form of low interest loans, tax credits, etc. Significant capital investments will be required in at least the following five manufacturing areas:

(1) Vehicle and driveline manufacturing facilities; (2) spare parts production facilities; (3) battery manufacturing facilities; (4) servicing equipment manufacturing facilities; and, (5) modification of vehicle assembly facilities.

Development of a sales/service infrastructure

In addition to developing manufacturing capabilities, a sales/service organization structured to the needs and requirements of electric hybrid vehicles will also have to be established. To a certain extent it may be possible to use the marketing and service establishments now in existence for conventional fuel consuming vehicles. This will depend to the extent existing manufacturers and dealers of conventional fuel consuming vehicles espouse the manufacture and sale of electric hybrid vehicles. While the marketing network could well be the same, new servicing facilities will be required for the maintenance of power plants of electric hybrid vehicles. Battery sales and service facilities will have to be greatly expanded. Innovative financing may have to be created to help the consumer finance these high initial costs items.

A vehicle refueling network will also have to be established. Serious consideration will have to be given to the power drawn and to the time needed for recharging, as well as to safety of recharging operations. It may be most effective or desirable not to have the individual owner of an electric hybrid vehicle personally recharge the battery system. Professionally managed recharging stations might be required. Finally, the skilled manpower needed to staff these service facilities would have to be trained and deployed.

Availability of raw materials

The consumption of some natural resources would change if electric hybrid vehicles were introduced into commerce in significant quantities The particular materials requirements would, of course, depend on the specific configurations of the vehicle being commercialized. For electric vehicles, the choice of battery is of significance, especially insofar as some of the advanced battery materials that are not presently consumed in massive commercial quantities. An example is lithium, needed for the lithium-aluminum iron sulfide battery. Other materials which might be impacted would include nickel, molybdenum, and antimony. The availability of advanced high-strength elements such as those required in flywheel hybrids could be an issue of concern.

The questions raised in this area include the availability of the needed natural resources to produce these raw materials, the U.S. reserves of these natural resources, and the manufacturing facilities needed to transform the mineral resources into the primary materials needed by the electric vehicle industry.

Impacts on the petroleum industry

A shift in the transportation sector to non-petroleum fuel consuming vehicles will impact the petroleum industry which derives a significant fraction of its income from the sale of motor fuels. If the shift were of a significant magnitude, there would result major perturbations in all phases of the industry. A first consequence might be the creation of imbalances in the petroleum refining industry. More severe consequences would be idling of valuable equipment in all sectors of the industry from exploration to delivery at the service station. The economic impacts of such a shift would be major unless any transition, even a well planned one, were gradual.

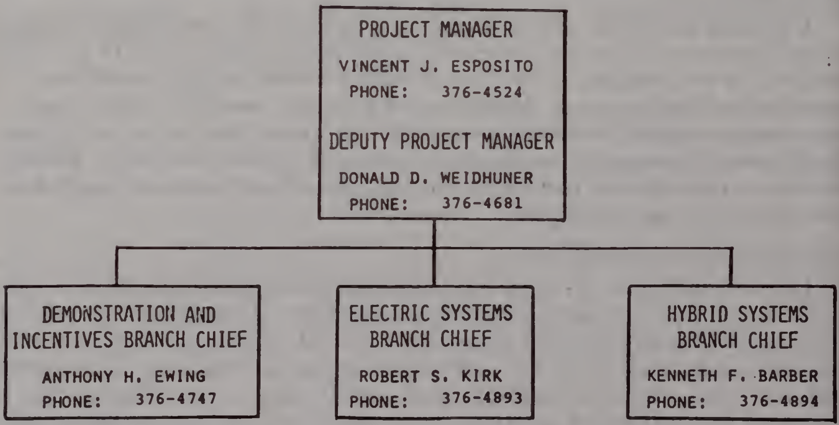
Modification of existing tax structures to include operation of electric and hybrid vehicles

The sale of gasoline and diesel fuel generates a significant tax revenue for all levels of government. Unless equivalent taxes were placed on electric hybrid vehicles, some of the monies needed to build, maintain, and operate the public roads would be lost. The nature of the type and level of road user tax that would be applied to vehicles that do not consume conventional fuels will be an issue in the development of their use in commerce.

ERDA

ELECTRIC AND HYBRID VEHICLE RESEARCH, DEVELOPMENT AND DEMONSTRATION PROJECT

ORGANIZATION CHART



POTENTIAL FOR USING ELECTRIC VEHICLES ON FEDERAL INSTALLATIONS

A Report by the Comptroller General of the United States

March 3, 1976

Many high-performance conventional vehicles are being used by Federal agencies for tasks which could be handled by lower performance vehicles that offer advantages of reduced costs, energy consumption, and air pollution.

This report compares the performance, cost, energy use, and environmental pollution characteristics of electric vehicles with conventional vehicles.

Comptroller General of the United States,
Washington, D.C.

B–135945

Hon. Gilbert Gude,
House of Representatives,
Washington, D.C.

Dear Mr. Gude: As you requested, we have reviewed the potential for using electric vehicles on Federal installations. Our work was divided into two phases. Phase I explored and studied the characteristics of electric vehicles and compared the performance, economics of operation, use of energy, and environmental pollution characteristics with conventional vehicles. Phase II assessed the potential of using these vehicles on Federal installations by visiting selected installations to examine facility traffic characteristics and use patterns. We limited our review to battery-powered vehicles as opposed to electric trains or buses energized through rails or overhead lines.

Only limited information on electric vehicle operational and maintenance costs is available. Consequently conclusions on replacing conventional vehicles with electric ones would not necessarily apply to all situations. However, we believe that many conventional, high-performance vehicles restricted to on-the-facility use could be replaced by electric vehicles or low-performance, gasoline-powered vehicles. Low-speed electric vehicles are economically attractive but many relatively high speed electrics are not. Replacing conventional vehicles with low-performance vehicles of either electric or conventional design would result in lower energy consumption and lower air pollution levels.

Our work is summarized below. Additional detail has been provided in the appendix.

—Electric vehicles can be grouped into two broad classes consisting of off-the-road and on-the-road type vehicles. Although electrics have been in use since the early 1900s, few on-the-road vehicles are currently in fleet service. However, there are more than 400,000 off-the-road electrics in service and their market is considered established. (See p. 1.)

—Electric vehicles are special purpose vehicles. Low-performance characteristics, such as short ranges, low acceleration and poor hill climbing ability, and often low, top speeds restrict their usefulness. (See pp. 4 to 6.)

—Electric vehicles do not produce exhaust gas emissions but they do contribute to air pollution when they use electricity generated in power plants fueled by coal or oil. In 1974, about 62 percent of electricity produced in the United States was generated from coal and oil fuel sources. Power plant stack gas emissions, like sulfur dioxide and oxides of nitrogen, can seriously aggravate the air pollution problem. (See pp. 6 to 9.)

—Electric vehicles use less petroleum. Much of the electricity used to recharge batteries of electric cars would come from generating plants using coal, nuclear energy, and hydropower. (See pp. 9 and 10.)

—Electric vehicles are not necessarily energy conserving. They will conserve energy as they replace high-powered conventional vehicles, particularly on routes characterized by low-speed, multistop driving. However, electrics are unlikely to conserve energy when replacing conventional cars with similar weight-to-power ratios such as subcompact cars. (See pp. 9 and 10.)

—Compared with conventional vehicles, electrics may or may not be economically attractive. Off-the-road electrics are likely to be economically attractive because their acquisition cost is often comparable to, or moderately higher than, the conventional vehicles they replace. On-the-road electric vehicles may be unattractive because acquisition costs often are between two to three times higher than those of comparable conventional vehicles. In such cases, the lower electric vehicle operation and maintenance costs are unlikely to offset acquisition cost during the lifetime of the vehicle. (See pp. 10 to 12.)

—Many vehicles on Federal installations are over-powered for the tasks they are assigned to do and could be replaced by electric vehicles or low-performance, gasoline-powered vehicles. (See pp. 12 to 15.)

As agreed with your staff we plan to send copies of this report to selected congressional committees and executive agencies 5 days after sending it to you.

Sincerely yours,

ELMER B. STAATS,
Comptroller General
of the United States.

APPENDIX I

BACKGROUND

Electric vehicles were in common use during the early 1900s but shortly thereafter on-the-road use was largely abandoned. Today few are being used on public roads. An attempt to market on-the-road electric trucks was made in the 1950s and again in the mid-1960s when interest for electric cars resurged. Both attempts failed due to lack of demand. Interest was revived in the late 1960s because electrics were seen as one possible solution to the Nation's air pollution problem and recent interest was stimulated because of the gasoline shortage.

However, high acquisition cost and performance limitations still restrict the demand for on-the-road electric vehicles.

Off-the-road use, on the other hand, has been established. For example, more than 197,000 electric golf carts are being used, representing about 75 percent of the golf cart market. Similarly, more than 200,000 electric material handling forklift trucks and more than 20,000 electric in-plant vehicles are being used nationally. Off-the-road use has been popular because the vehicles serve special needs and they are often economically attractive.

ADVANTAGES AND DISADVANTAGES OF ELECTRIC VEHICLES

Electric vehicles have many potential advantages over conventional vehicles. They (1) operate free of exhaust fumes—although they indirectly contribute to air pollution through utility power plant emissions, (2) can use an alternative energy source to gasoline, (3) may conserve energy, (4) are expected to be more reliable, and (5) are likely to be less expensive to operate and maintain than conventional vehicles.

On the other hand, electrics have several major disadvantages compared to conventional vehicles. First, performance limitations restrict use to special purpose applications, such as short-range delivery vehicles or short-range commuter cars. Second, acquisition costs for on-the-road electric vehicles can be as much as two to three times higher than conventional vehicles; battery replacement costs can also be high. Third, use of electrics may require retraining mechanics who are not familiar with the electric drive train and, at present, long lead times for spare parts may cause excessive out-of-service time.

The primary component restricting electric vehicle performance is the battery. Currently, low battery energy densities restrict vehicle range and limited power outputs restrict acceleration, top speed, and hill climbing ability. For example, as much as 500 pounds of battery may be required to provide the mechanical energy obtainable from a single gallon of gasoline. The equivalent of a 10-gallon gas tank is therefore prohibitively heavy.

Limited performance restricts electric vehicles to special purpose applications

Today's electric vehicles are restricted to special purpose applications because of their limited performance characteristics. They appear to be ideally suited for low-speed, multistop, fleet applications. Fleet vehicles can be directed to cover a relatively fixed daily range and return to homebase at night where batteries can be recharged and trained mechanics can maintain and repair the electric drive train. Electric motors naturally adapt to low speed, multistop service; energy consumption is minimal because there is no energy consumption when the vehicle is stopped, coasting, or decelerating. For more general uses, the apparent advantages of electrics over conventional vehicles are offset by their short range, slow acceleration, low top speeds, poor hill climbing capabilities and certain safety hazards as discussed below.

Electric vehicles have a short range

Limited range is the major restriction factor for electrics. Electric vehicle range is not only limited but varies significantly with driving and route characteristics. For example, a ¼-ton Postal Service jeep used on a route with 300 stops needs its battery recharged after 29 miles. The same vehicle used for continuous driving at about 35 mph can travel 45 miles between rechargings. A ½-ton delivery van can have a nonstop range of about 40 miles when driving at 30 mph. At a speed of 50 mph this range is decreased to 26 miles and when operating in a residential driving environment the approximate range is 30 miles.

An electric golf cart can make two 18-hole rounds on flat courses before needing a charge, but can only be used for one 18-hole round if the golf course is hilly. In cold, winter weather vehicle ranges are likely to be less because battery energy storage capacity is estimated to be reduced by about 20 to 25 percent.

Electric vehicles accelerate slowly, have low top speeds, and poor hill climbing capabilities

Electric vehicle acceleration, top speed, and hill climbing ability depend largely on the amount of power available from the battery. Battery limitations restrict power availability to much lower levels than those available for conventional vehicles. Moreover, power availability and vehicle range are inversely related. The higher the available power levels the shorter is the vehicle range. Consequently designers have an incentive to keep electric vehicle power requirements low.

There appear to be no uniform regulations specifying acceleration requirements for automobiles, nor is there any concrete evidence as to whether vehicle acceleration performance has a bearing on accident avoidance. A desirable condition seems to be that motor vehicles should not impede traffic. Studies conducted by the Copper Development Association conclude that to keep up with light urban traffic requires an ability to accelerate to 30 mph in 10 seconds, moderate traffic requires reaching 25 mph in 10 seconds, and heavy traffic requires acceleration to 18 mph in 10 seconds.

We observed that some on-the-road electrics meet the tested acceleration criteria. For example, an electric ½-ton van met all three traffic requirements. Others, like the ¼-ton Postal Service mail delivery van in Cupertino, California accelerated to 20 mph in 9 seconds and to 30 mph in 15 seconds and thus only meets the heavy urban traffic acceleration rates.

The new electric ¼-ton Postal Service mail delivery jeep will be slower and will require about 20 seconds to accelerate to 30 mph. The electrics have less than one-quarter the power of the conventional jeep.

Compared to conventional vehicles, on-the-road electrics often have low, top speeds. For example, many conventional light trucks have top speeds exceeding 65 mph, while top speeds of most electric on-the-road delivery vehicles reviewed range from 33 to 50 mph.

Some electrics can climb more than 25 percent grades, but apparently only at low speed. For example, the ¼-ton electric jeep with a top speed of 33 mph, slows down to 16 mph on a 10-percent grade. Data on a ½-ton electric delivery van with a top speed of about 50 mph indicates that the vehicle slows down to down 29 mph on a 5 percent grade, and to 10 mph on a 20 percent grade.

Safety hazards

The electric vehicle batteries may be hazardous in an accident because exposure to diluted sulfuric acid from damaged batteries could cause skin burns or blindness. One study showed that locating the heavy batteries in one large container runs counter to current design trends dictated by safety requirements. Batteries also have been known to explode when improper charging procedures are used or when shorted. Charging and discharging lead acid batteries liberates hydrogen gas which can be ignited by a spark. Vehicle safety experts agree that light weight electric vehicles have definite safety disadvantages in mixed traffic accident situations. In addition, low vehicle top speeds can constitute a traffic hazard when mixed with faster traffic.

Electric vehicles can contribute to air pollution

Whether or not use of electrics helps reduce air pollution depends on the local characteristics of the electricity power generation process. While electrics do not produce vehicle exhaust gas emissions, they transfer the air pollution emission problem to the electricity generating plant. To the extent that the vehicles use electricity generated from such sources as hydropower and nuclear energy, they do not contribute to air pollution. However, electrics that use electricity generated from coal and oil sources contribute to air pollution.

Electric vehicle use of electricity will vary. One test showed electric vehicles consuming .5 kilowatthour (kWh) per mile. If driven 30 miles a day it would consume 15 kWh daily. A 25-inch solid state console color TV is rated at .18 kWh. If used for 6 hours daily it would use about 1 kWh per day.

In 1974, about 62 percent of the electricity generated in the United States was coal and oil based. While the Federal Energy Administration expects electricity production to double by 1985, most of the new electricity generation facilities are expected to be of the clean nuclear type. Consequently, by 1985 the relative share of such dirty fuels as coal and oil used for generation of electricity, is expected to decrease to less than 50 percent.

The air pollution characteristics of power plants differ from pollution emissions of conventional vehicles in both type of pollutant and in the way the pollutant is emitted into the atmosphere. Power plants are the primary source of sulfur dioxides, a very hazardous pollutant. Power plants also emit large quantities of nitrogen oxides and particulate matter.

The power plant emission process also differs from that of automobiles. The former discharges pollutants generally from tall stacks which are removed from the ground surface while conventional vehicles emit pollutants at the street level. Consequently, the concentration of power plant originated pollutants is usually substantially reduced at ground level due to dispersion in the surrounding air volume.

Power plant pollution extends over wide areas. According to the Environmental Protection Agency:

"The impact of power plants on air quality varies across the country. In some areas the impact of power plants is relatively slight, but in other areas power plants alone cause primary standards to be exceeded. Use of high-sulfur coal, for example, is predominant in our East-Central States where such coal is mined. The detrimental impact of power plants on air quality in these States is substantial, especially when these States are compared to those where gas or low-sulfur oil is used as a fuel."

Conventional vehicles are primary sources of carbon monoxides, hydrocarbons, and nitrogen oxides. Under appropriate weather conditions hydrocarbons and nitrogen oxides react in the atmosphere to form photochemical smog. Both nitrogen oxides and photochemical smog represent serious health hazards.

Ongoing enforcement of vehicle emission controls is expected to eventually reduce automobile-caused air pollution to secondary importance relative to stationary sources.

A comparison of approximate pollutant emissions in grams per mile is shown in the table below for conventional, as well as, electric light duty vehicles.

COMPARISON OF APPROXIMATE CONVENTIONAL AUTOMOBILE EXHAUST GAS EMISSION CHARACTERISTICS WITH ELECTRIC VEHICLE EQUIVALENT POWERPLANT EMISSIONS [1]

[In grams per mile]

Pollutant	Estimated precontrol emissions	Conventional car Federal emission standards [2]		Electric vehicle equivalent powerplant emissions [3]		
		1975	1977	Coal	Oil	Gas
Hydrocarbons	8.00	1.50	0.41	0.03	0.03	0
Carbon monoxide	68.00	15.00	3.40	.09	.05	.04
Oxides of nitrogen	8.00	3.10	[4] .40	[5] 4.67–1.53	1.70	1.39
Sulfur oxides	.13	.13	[6] .13	3.24	2.58	0
Particulates	(7)	.10	[6] .10	[5] .86–7.37	.13	.03
Total	84.13	19.83	4.44	8.89–12.26	4.49	1.46

[1] Data obtained from studies sponsored by the U.S. Environmental Protection Agency. Powerplant emissions correspond to an electricity vehicle energy consumption of 0.5 kWh a mile, and uncontrolled emissions when burning 1 percent sulfur content powerplant fuels; powerplant efficiency was assumed to be 35 percent, and electricity transmission efficiency as 91 percent.

[2] Emission standards refer to automobile emission levels after a certain number of miles have been driven. New cars have lower emission levels.

[3] 0.5 percent sulfur content fuel oils would produce ½ the sulfur oxide emission levels shown in the table.

[4] The conventional car oxides of nitrogen emission standard of 0.4 grams a mile is likely to be revised upward.

[5] Bituminous coal with 5.1 percent ash content. Emission levels vary with boiler type. Coals which emit higher levels of oxides of nitrogen emit lower levels of particulates.

[6] The Environmental Protection Agency issued no standards regarding automobile sulfur dioxide emissions.

[7] We obtained no data regarding automobile particulate emissions before adopting Federal emission standards.

The differences emitted by the two types of vehicles are clearly visible. When power plant emissions are uncontrolled, electric vehicles can give rise to more than 10 times the amount of sulfur oxides emitted a mile than conventional vehicles. Emissions of oxides of nitrogen and particulates are also high, while hydrocarbon and carbon monoxide emissions are negligible.

According to a representative of the Environmental Protection Agency, power plant particulate emissions often do not represent a problem because stack gas screening devices have been fairly successful. However, the removal of sulfur and nitrogen oxides from the stack gases is more difficult.

Many utility companies comply with sulfur oxide emission requirements by using scarce, low sulfur levels. For example, in Los Angeles where natural gas shortages recently forced a switch to low sulfur fuel oil, local regulations required using 0.5 percent or less sulfur content.

Electric vehicles can use an alternative source of energy to gasoline, but they are not always energy conserving

Electric vehicles consume energy in that the electricity required to recharge batteries is derived from energy consuming power plants. However, one argument for electric vehicles is their potential for using an alternative energy source to gasoline. This is expected to be particularly important in the future when, according to the Federal Energy Administration, electricity generation is expected to be primarily coal, hydropower and nuclear power based. In 1972 more than 60 percent of the electricity produced in the United States was derived from such sources and it is expected, that by 1985, plants using fuel oil and natural gas will decrease and more than 75 percent of the electricity will be derived from these alternative energy sources.

When electrics replace high performance conventional vehicles they can conserve energy. For example, tests indicated that a conventional ¼-ton Postal Service mail delivery jeep in Cupertino, California, consumes approximately 21,000 British thermal units per mile while the electric vans, which replaced the jeeps, on the average consume only about 13,900 [1] British thermal units per mile. This represents a decrease in energy consumption of approximately 34 percent. The difference is largely based on weight to power ratio considerations. The jeep has about five times the acceleration capability of the electric van and fast accelerations are energy wasteful.

According to the Environmental Protection Agency, if internal combustion engine vehicles were to be designed to offer a reduced performance equivalent to that of electric vehicles, conventional cars could provide equal or better fuel economy. A study regarding the impact of future use of electric cars in the Los Angeles basin found that the lead-acid battery car consumes more energy per mile than conventional subcompacts, such as the 1974 Pinto. The lead-acid electric car was estimated to consume about 8,000 British thermal units per mile (inefficiencies of the power plant and the distribution system were considered) versus about 6,000 British thermal units for the Pinto. Modest improvements in energy consumption efficiencies offered by advanced batteries are likely to be offset by engineering improvements in conventional car design.

Electric vehicles may or may not be economically attractive for Government use

From an economic viewpoint, the electric vehicle may offer advantages over conventional vehicles in lower maintenance and energy costs, and higher reliability. Disadvantages are often high first costs, high battery replacement cost, relative inflexibility concerning variable task assignments, and the potential need for training auto mechanics so that they can diagnose and repair problems of electric drive trains.

The absence of reliable electric vehicles life cycle cost data makes detailed cost analysis impractical. A cost study by one vehicle manufacturer indicates that electrics tend to be economically attractive if (1) acquisition costs are less than about 200 percent of equivalent costs for conventional vehicles, (2) electricity cost is three cents per kWh or less, (3) gasoline costs are about 57 cents per gallon or higher, and (4) maintenance costs for electrics are about one-half those of conventional cars. Using these criteria we noted that off-the-road electrics, such as inplant type vehicles, and low-cost, on-the-road vehicles would be economical to use at some Federal installations. these vehicles have acquisition costs comparable to the conventional vehicles they replace and annual battery replacement costs are relatively low. On the other hand, many on-the-road vehicles, such as the ¼-ton electrical Postal Service jeep, an electric ½-ton delivery van, and a 25-passenger electric bus are estimated to be economically unattractive. Based on the above considerations, high acquisition costs for these vehicles are not likely to be offset by lower maintenance and energy costs.

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[1] In arriving at the cited figure we considered the energy lost to convert fossil fuels to electricity at power plants, as well as the energy loss in transmitting electricity from the power plant to the point of use.

On-the-road electrics may have acquisition costs more than twice as high as conventional vehicles purchased by the Government because (1) the electric vehicle drive train is often more costly, (2) the vehicles are often of sturdy, high quality construction, and (3) electric on-the-road vehicles are usually hand built because of low demand.

For example, the cost of conventional gasoline powered three-wheel trucks, two-passenger electric cars and in-plant electric trucks (all off-the-road vehicles) ranged from about $2,000 to $2,500. The cost of a conventional ½-ton pick-up truck was about $3,100. Recently 350 electric jeeps (on-the-road vehicles) were purchased by the Postal Service at a unit price of $5,595 at a time when the conventional jeep was costing them $2,175.

Acquisition costs for electrics also often include costs of batteries, battery charger, extra batteries, and equipment needed to exchange batteries. Not included is the cost of constructing a charging facility. If required, this cost can be substantial. For example, in one instance a bus company had to pay an unexpected $40,000 for construction of a charging facility for three electric buses.

In general, electric vehicle repair and maintenance costs vary with vehicle type, usage, and age. According to one manufacturer average maintenance costs can be assumed to be approximately one-half those of conventional cars. For example, national average data on electric forklift trucks indicate that maintenance material costs are 45 to 53 percent lower than for gasoline powered units. Also, maintenance labor costs are 30 to 39 percent lower. Electric vehicle maintenance costs are lower primarily because they have fewer moving parts and no requirements for tuneups, oil changes, or other periodic services normally associated with internal combustion engines.

According to published data, maintenance cost variations associated with electric milk delivery trucks in Great Britain indicate variations ranging from 56 percent cost reductions, to 2 percent cost increases, when compared to conventional trucks. One theoretical study points out that removal of the internal combustion engine system would eliminate about 72 percent of the car service labor hours. Added service requirements of the electric power train are expected to be minimal except perhaps for battery service requirements.

The total battery replacement costs to be incurred during the electric vehicles anticipated life span are often not known because of uncertain battery life expectancies. Battery life depends strongly on usage characteristics. Two types of batteries are being used. Light vehicles often use a series of automotive batteries which are relatively small. In 1974 the Federal Government paid about $180 to replace a battery set. Life expectancy is about 1 year. Heavy vehicles such as buses, delivery trucks, or the ¼-ton Postal Service jeeps use semi-industrial type batteries which are relatively bulky and cost from about $1,600 to $6,000 a set. The latter batteries have life expectancies ranging from about 4 to 6 years.

Electric vehicles are likely to be more reliable

Electric vehicles are considered to be more reliable than conventional vehicles because the electric drive train has fewer moving parts, fewer vibrations, and the motor provides slower vehicle acceleration. Electric vehicle traction motors have only two metal-to-metal moving parts, and they have a record of high reliability.

For example, during almost 1 year of operation the U.S. Post Office in Cupertino, California experienced only 11 days when any of its 30 electric mail delivery vans were out of service. This amounts to an out-of-service time percentage of approximately one-tenth of 1 percent. According to the Postal Service's western region vehicle service manager this downtime was considerably less than that of conventional jeeps.

USE OF ELECTRIC VEHICLES IN FEDERAL SERVICE

Special purpose electric vehicles, such as material handling forklift trucks and golf carts, are already in service on Federal installations on a routine basis. Other types of on-and off-the-road electric vehicles have performance characteristics which would favor their use, but the absence of reliable cost data makes it difficult to measure their economic attractiveness.

Various agencies have experimented with electric cars. For example, the Air Force assessed potential use of inplant and on-the-road electric vehicles for on-the-facility use in 1970 and 1971. They concluded that off-the-road electrics, with 10 to 13 mph top speeds, might be economically usable in areas with 15 mph speed limits. Some potential tasks would be transporting flight crews and maintenance equipment in flight line areas, and nighttime security patrols in housing areas. It was also concluded from the tests that electrics could not replace conventional vehicles for some of the work tasks. The Air Force also tested an electric on-the-road delivery van and a 11-passenger bus but recommended against using the vehicles primarily because of the high purchase price and operations costs.

The National Park Service in Washington, D.C., is testing more than 15 off-the-road electrics as well as an on-the-road 25-passenger bus. Vehicle performance appears to be adequate, but operations costs are not being monitored.

The Goddard Space Flight Center has been experimenting with two 12-mph, off-the-road electric vehicles to provide transportation for maintenance supervisors. The electrics replaced a conventional station wagon and a privately owned car. Users are apprehensive about personal safety while driving the low-speed electrics on facility roads which have 25 mph speed limits. In addition, the drivers mentioned that the small electrics slow down to objectionable slow speeds when driving up hill.

The National Oceanic and Atmospheric Administration has been using 3 electrics for about 3 years. Top speed of the vehicles is 28 mph and use has been confined to facility roads. Performance and maintenance requirements have been judged adequate but operation and maintenance cost records have not been kept.

In addition, the U.S. Postal Service has been evaluating the feasibility of using electrics for residential mail delivery service for many years. Feasibility from a performance point of view has been demonstrated for selected routes but operational evaluations are still in process. Unit lease costs, including energy and maintenance for 30 on-the-road experimental vans used for mail delivery in Cupertino, California, are about $7.50 a day. In contrast, the Postal Service average for a conventional mail delivery car lease costs is only $3.00 including fuel cost.

To assess electric vehicle characteristics under fleet operating conditions, the Postal Service has ordered 350 electric on-the-road jeeps. If on-the-road electrics prove successful, the Postal Service estimates that vehicles on more than 30,000 mail routes could be replaced by electrics.

We believe that further potential exists for using electric vehicles on Federal installations. For example, relatively high performance. conventional vehicles used for on-the-facility short range applications at three Department of Defense facilities are shown in the table below.

APPENDIX I

EXAMPLES OF CONVENTIONAL VEHICLES POTENTIALLY REPLACEABLE BY ELECTRIC VEHICLES

Facility and vehicle type	Number of vehicles in class	Vehicles estimated to be potentially repleceable by electrics [1]	Average daily mileage	Vehicle application and comments
McClellan Air Force Base:				
29-passenger bus	17	11	49	On-the-facility bus service.
1-ton metrovan	40	40	22	Used for mail distribution, aircraft maintenance, and delivery of flight crews on base.
½-ton pickup	124	62	46	Onbase repair parts and cargo distribubution; security patrols.
Fort Ord Army Base:				
¾-ton engineering utility truck	126	63	[2] 17	Onbase maintenance and repairs.
½-ton pickup	150	85	40	Onbase cargo transportation and personnel transportation; messenger service.
Long Beach Naval Shipyard:				
¾-ton utility truck	29	12	26	Onbase maintenance and repairs.
½-ton pickup	116	50	45	Onbase delivery service; personnel transportation; and security police.
3-wheel, low speed truck	41	41	[3] 13	On-the-facility messenger and light repair service.

[1] Criteria: Maximum daily use would be 40 miles and top speed requirement would be 25 miles per hour.

[2] Based on a sample of 10 vehicles.

[3] Based on a sample of 4 vehicles.

The table contains estimates of the number of vehicles which could be used exclusively onbase. The average daily mileages shown include long distance offbase driving. Vehicles used only onbase can be expected to have shorter average daily travel requirements. For example, at McClellan Air Force Base most 1-ton metrovans are used for onbase functions such as mail handling, moving flight line aircraft maintenance tools and equipment, and transporting flight crews. Average daily mileage requirements are only 22 miles. On the other hand, many ½-ton pick-up trucks have missions which require offbase driving and the average daily trips are much longer.

Speed limits on the three military installations visited varied from about 8 to 35 mph. Generally, speed limits were 25 mph, except at the Long Beach Naval Shipyard where the speed limit on the main thoroughfares was 20 mph. In special purpose areas, such as Air Force industrial areas and along the flight line, speed limits were 15 mph. On the other hand, speed limits on some facility approach areas seemed too high for many electric vehicles.

CONCLUSIONS

Acquisition costs for off-the-road electric vehicles are generally comparable or lower than the cost of conventional vehicles they could replace. However, acquisition cost for some on-the-road electrics such as the electric Postal Service jeeps, is over twice as much as comparable conventional vehicles currently used by Federal agencies. Acquisition cost is high because the electric drive train is more costly to manufacture than the drive train of conventional cars and battery costs are high. When electric vehicles replace conventional vehicles there is also a need for additional auxiliary equipment such as a battery charger, battery exchanger, and a battery charging facility.

It is estimated that electric vehicle maintenance and energy costs are considerably lower than those for comparable conventional vehicles. However, except for special cases, reliable operations and maintenance data is lacking for life cycle analysis and does not allow a realistic economic cost assessment.

Many high performance conventional vehicles are being used by Federal agencies to conduct tasks which could be handled with vehicles of lower performance characteristics. From a performance point of view we see no reason why these vehicles could not be replaced by electric vehicles or equivalent low performance gasoline powered vehicles. Use of low performance vehicles, wherever possible, would result in lowered energy consumption, and in lower air pollution levels. Several Federal agencies have initiated independent experimental programs to assess usefulness of electric vehicles in their operations.

SCOPE

Our examination of the potential for using electric vehicles in the Federal Government included visits to three military installations, two Postal Service sites, and facilities of three Federal civil agencies. Our observations are based on interviews, examination of records, and a review of pertinent documents. In addition, we contacted representatives of pertinent Federal agencies, two trade associations, five electric vehicle manufacturers, and potential commercial and municipal electric vehicle users. We also reviewed numerous publications depicting the current state of the art for electric vehicles.

Entities contacted are shown below:

McClellan Air Force Base, Sacramento, Calif.
Fort Ord Army Base, Fort Ord, Calif.
Long Beach Naval Shipyard, Long Beach, Calif.
Postal Service sites at San Bruno, Calif., and Cupertino, Calif.
Goddard Space Flight Center, National Aeronautics and Space Administration, Greenbelt, Md.
National Park Service, Washington, D.C.
National Oceanic and Atmospheric Administration, Washington, D.C.
Department of Transportation, Washington, D.C., and San Francisco, Calif.
Environmental Protection Agency, Washington, D.C.; Ann Arbor, Mich.; and San Francisco, Calif.
National Science Foundation, Washington, D.C.
The Electric Vehicle Council, New York City, N.Y.
The Battery Council International, Burlingame, Calif.
Various commercial companies and city transportation departments
Various electric and conventional vehicle manufacturers.

FEDERAL MOTOR VEHICLE FLEET REPORT FISCAL YEAR 1976

Source: Federal Motor Vehicle Fleet Report (excerpts) for fiscal year ending June 20, 1976, published June 1977, by General Services Administration, Federal Supply Service.

BACKGROUND

This report summarizes data forwarded to GSA by Federal agencies on Standard Form 82, Agency Report of Motor Vehicle Data, and Standard Form 82-D, Agency Report of Sedan Data. Some tables are developed from data which all agencies are required to report; other tables show data submitted by the 18 agencies and bureaus which hold 2,000 or more vehicles. These 18 "large fleets" account for approximately 94.0 percent of the vehicles in the total Federal fleet.

In addition to using their own vehicles, agencies make extensive use of vehicles obtained from the 100 interagency motor pools, operated by GSA, in support of agency programs. To further supplement their needs, agencies obtain vehicles from commercial rental firms and/or permit Government employees to use privately owned vehicles (POV), subject to reimbursement. Agencies are not required to report POV mileage or cost to GSA on SF 82 and SF 82-D. However, the use of POV for conduct of official business is a significant transportation cost which fleet managers should document and compare with the cost of using agency-held, interagency, or commercial rental vehicles.

The following two tables show worldwide data for the federally owned fleet.

TABLE 1.—ALL AGENCIES—WORLDWIDE FEDERALLY OWNED MOTOR VEHICLES INVENTORY AS OF JUNE 30, 1976

[Number of vehicles]

	Sedans	Station wagons	Ambu-lances	Buses	Trucks	Total
Civilian agencies:						
Domestic	62, 947	6, 474	422	2, 626	80, 883	153, 352
Foreign	1, 455	701	1	49	2, 612	4, 818
Total	64, 402	7, 175	423	2, 675	83, 495	158, 170
U.S. Postal Service: Domestic (total)	1, 359	([1])	([1])	([1])	120, 061	121, 420
Defense agencies:						
Domestic	17, 604	3, 703	2, 224	5, 051	87, 449	116, 031
Foreign	4, 748	845	662	2, 937	20, 413	29, 605
Total	22, 352	4, 548	2, 886	7, 988	107, 862	145, 636
All agencies .						
Domestic	81, 910	10, 177	2, 646	7, 677	288, 393	390, 803
Foreign	6, 203	1, 546	663	2, 986	23, 025	34, 423
Total	88, 113	11, 723	3, 309	10, 663	311, 418	425, 226

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[1] These vehicles not separated in USPS data system.

TABLE 2.—LARGE FLEETS [1]—WORLDWIDE FEDERALLY OWNED MOTOR VEHICLES COST, MILEAGE, AND FUEL CONSUMPTION, JULY 1, 1975, TO JUNE 30, 1976

All agencies	Domestic	Foreign	Total
Total cost	$608, 775, 757	$55, 736, 943	$664, 512, 700
Total miles operated	2, 832, 882, 000	258, 087, 000	3, 090, 969, 000
Overall average cost per mile	$0. 21490	$0. 21596	$0. 21499
Total gallons of fuel	284, 556, 625	28, 743, 368	[2] 313, 299, 993

[1] Agencies holding 2,000 or more vehicles (94 percent of total fleet).
[2] Equivalent to the gasoline content of 16,149,484 barrels of crude oil.

FIVE-YEAR TRENDS—SELECTED DATA

Worldwide data

Worldwide federally owned vehicle inventories of all agencies for fiscal years 1971 through 1976 are shown in table 3a. Table 3b illustrates data for large fleets: miles operated, average miles per vehicle year, total cost, and fleet average cost per mile. The number of vehicles of all agencies increased from 416,406 in fiscal year 1971 to 425,226 in fiscal year 1976, a 2.1-percent increase, while large fleet mileage increased by 10.3 percent. During the 5-year period, average miles per vehicle year of the large fleets, a key measure of vehicle utilization, decreased 13.1 percent while average cost per mile increased 60.0 percent.

TABLE 3a.—ALL AGENCIES—WORLDWIDE FEDERALLY OWNED MOTOR VEHICLES INVENTORY CHANGES, FISCAL YEARS 1971–76

[Number of vehicles]

	Fiscal year—					
	1976	1975	1974	1973	1972	1971 base year
Number	425, 226	420, 784	422, 253	420, 044	413, 681	416, 406
Annual change	+4, 442	−1, 469	+2, 209	+6, 363	−2, 725	
Percent change	+1.0	−0. 3	+0. 5	+1. 5	−0. 7	

TABLE 3b.—LARGE FLEETS—WORLDWIDE FEDERALLY OWNED MOTOR VEHICLES OPERATING AND COST DATA, FISCAL YEARS 1971–76

	Fiscal year					
	1976	1975	1974	1973	1972	1971 base year
Miles operated:						
Miles	3, 090, 969, 000	3, 009, 679, 000	2, 969, 508, 000	2, 957, 557, 000	2, 995, 468, 000	2, 802, 076, 000
Annual	+81, 290, 000	+40, 171, 000	+11, 951, 000	−37, 911, 000	+193, 392, 000	
Percent change	+2.7	+1. 4	+0. 4	−1. 3	+6. 9	
Average miles per vehicle year:						
Average miles	8, 602	8, 139	8, 169	8, 740	9, 220	9, 904
Annual change	+463	−21	−580	−480	−684	
Percent change	+5. 7	−0. 3	−6. 6	−5. 2	−6. 9	
Total cost:						
Total cost	$664, 512, 700	$612, 242, 447	$534, 908, 203	$475, 195, 789	$459, 187, 913	$376, 599, 528
Annual change	+52, 270, 253	+77, 334, 244	+59, 712, 414	+16, 007, 876	+82, 588, 385	
Percent change	+8. 5	+14. 5	+12. 6	+3. 5	+21. 9	
Fleet average cost per mile:						
Cost per mile	$0. 2150	$0. 2034	$0. 1801	$0. 1607	$0. 1533	$0. 1344
Annual change	+0. 0116	+0. 0233	+0. 0194	+0. 0074	+0. 0189	
Percent change	+5. 7	+12. 9	+12. 1	+4. 8	+14. 1	

Domestic data

A review of tables 4a and 4b indicates that significant changes have occurred in the federally owned domestic motor vehicle fleet since fiscal year 1971. Total mileage for large fleets in fiscal year 1976 was 14.4 percent higher than in fiscal year 1971.

Total cost of operation for the large fleets soared from $334.5 million in fiscal year 1971 to $608.8 million in fiscal year 1976, an increase of 82.0 percent. (A considerable portion of the increase in fleet costs can be attributed to inflation, measured by the Consumer Price Index—Transportation, which rose 38.8 percent during this 5-year period.) A comparison of the domestic fleet average cost per mile shows an increase from 13.50 cents to 21.49 cents or 59.2 percent.

Sedan mileage increased by 26.2 percent and vehicle years rose 25.8 percent while average miles per vehicle year increased by only 43 miles or one-third of 1 percent. The total cost for sedans increased 106.6 percent. Sedan cost per mile rose from 7.57 cents to 12.39 cents for an increase of 63.5 percent.

Trucks, which represent approximately 75 percent of the Federal fleet, show an increase in mileage of 13.9 percent, and a 37.9 percent increase in vehicle years of operation. Consequently, truck utilization declined 17.4 percent, from 8,831 average miles per vehicle year in 1971 to 7,295 in 1976.

During the same 5-year period, the total operational cost for trucks increased by 81.9 percent. The average cost per mile increased 59.7 percent from 15.67 cents to 25.02 cents.

In summation, the data clearly show that during the 5-year period vehicle fleets have increased more in size than in total operated mileage. This poor utilization of vehicles undoubtedly has contributed to the increase in cost per mile. Federal fleet managers at every level of responsibility need to provide safeguards against the acquisition (or retention) of vehicles which cannot be economically utilized.

Materials, labor, and contractual services

In table 12 of this year's report, the costs for the two major categories, materials and labor and contractual services, are combined. They amounted to $343.3 million or 71.4 percent of the total direct domestic large fleet cost of $481.0 million (table 15). In fiscal year 1976, costs for material, labor, and contractual services increased by $38.9 million, or 12.8 percent. Increases in these costs differed widely for the various vehicle classes. They ranged from 6.4 percent for buses to 23.2 percent for ambulances. For sedans the increase was 11.9 percent and for station wagons 13.1 percent. Correspondingly, cost per mile increased for all vehicle types with the exception of 3-ton-and-over trucks. These vehicles actually showed a reduction of two-thirds of 1 percent in cost per mile, which was partly due to the increased miles per vehicle year of operation. Any reduction in cost per mile, however small, is encouraging.

In an effort to reduce costs for materials, labor, and contractual services fleet managers should: Periodically review all operating and maintenance costs; seek to obtain lower fuel prices through arrangements with other agencies for cross-servicing and use of self-service pumps; periodically review maintenance programs to ensure that all vehicle manufacturers' maintenance requirements have been incorporated; evaluate the cost effectiveness of scheduled inspections (number of items and frequency); monitor the cost effectiveness of the mix of in-house and commercial shop services and repairs; and fully utilize the provisions of vehicle manufacturers' warranties.

Vehicle depreciation

Vehicle depreciation, the difference between the purchase price and the projected sale price, is charged to operating costs to create a reserve for the purchase of replacement vehicles. It is the largest single expense item in the maintenance of a motor vehicle fleet. Depreciation should reflect the capitalized cost of a vehicle projected over its planned useful life. Depreciation for the domestic large fleets, like other costs, has increased during fiscal year 1976 by $9.4 million or 7.6 percent.

Formulas used to compute depreciation costs should reflect, as nearly as possible, year-to-year actual depreciation of the vehicles. Agency control over acquisition cost is limited; however, sales recovery can be maximized through judicious reconditioning of used vehicles prior to sale. GSA strongly advocates the development of a reconditioning program to effect progressively higher recoveries from the sale of used vehicles. For further information on vehicle reconditioning, contact the General Services Administration (FZM), Washington, DC 20406.

Accident costs

Accident costs reported for fiscal year 1976, table 14, totaled $4.8 million, an increase over fiscal year 1975 of $242,668 or 5.4 percent. A comparison of fiscal year 1976 with fiscal year 1975 (table 15 of last year's report) shows extreme contrasts in accident cost changes for the various vehicle classes. They ranged from a reduction of 67.4 percent for ambulances to an increase of 72.0 percent for trucks (1-ton and under, 4-wheel drive). Accidents costs decreased by a total of $418,600 for five vehicle classes (sedans, station wagons, ambulances, buses, and trucks—3 tons and over), and increased by a total of $661,268 for three vehicle classes (1-ton and under trucks—both 2-wheel and 4-wheel drive, and 1½ to 2½-ton trucks).

The accident costs shown in this report are net figures; i.e., total vehicle repair costs less any amounts reimbursed by private parties and therefore represent only a fraction of the total cost effect of accidents involving Federal vehicles. To determine the total cost of accidents, agencies would have to record data such as the following: accident investigation and reporting costs; appraisal fees; capital losses of unrepairable vehicles; legal costs; settlement of tort claims; and costs relating to injury and death. Thus, the true costs of accidents is many times the $4.8 million reported.

Most accidents could be prevented. Initial and frequent refresher courses in defensive driving can help reduce accidents. Agency fleet managers can obtain advice and direct assistance for such courses by contacting Motor Equipment Services Division personnel at the nearest GSA regional office.

Indirect costs—domestic large fleets

Indirect costs represent charges in a motor vehicle fleet operation which cannot readily be identified with a specific vehicle or vehicle class. They include indirect labor, administrative and fiscal services, rent, improvements, amortization, utilities, shop equipment depreciation and maintenance, tools, communications, travel, supplies, and other miscellaneous costs. Since last year, indirect costs rose 9.7 percent while the Consumer Price Index increased 5.8 percent, a difference of 3.9 percent.

SEDAN FLEET

The impact of Public Law 94–163, Energy Policy and Conservation Act of 1975 (15 U.S.C. 2001 *et seq.*) on the procurement of sedans in the Federal fleet is reflected by the data in table 5. The total size of the sedan fleet increased by 5,548 vehicles, or 7.3 percent, from 76,362 vehicles at the beginning of fiscal year 1976 to 81,910 vehicles at the end. The most significant increase was in the compact Type IB category in which the number of acquisitions increased by 5,715 or 126.2 percent.

Future fleet reports should continue to reflect a steady shift toward smaller passenger vehicles because fiscal year 1977 will be the first year in which a significant number of sedan acquisitions will be made under the requirements of Public Law 94–163 (15 U.S.C. 2001 *et seq.*).

TABLE 5.—ALL AGENCIES—DOMESTIC SEDANS, BY TYPE[1] INVENTORY CHANGES JULY 1, 1975 TO JUNE 30, 1976

[Number of vehicles]

	Subcompact type 1A	Compact type 1B	Intermediate type II	Standard type III	Medium type IV	Heavy type V	Limousines, type VI	Special types	Not reported by type	Total
On hand July 1, 1975	214	11, 764	26, 184	36, 496	183	147	7	7	1, 360	[2] 76, 362
Acquisitions	365	10, 245	1, 944	2, 933	116	57	3	3	181	15, 847
Disposals	48	336	4, 998	4, 843	31	29	----	----	14	10, 299
On hand June 30, 1976	531	21, 673	23, 130	34, 586	268	175	10	10	1, 527	81, 910
Net change	+317	+9, 909	−3, 054	−1, 910	+85	+28	+3	+3	+167	+5, 548

[1] Sedan types as itemized in Federal Specification KKK-A-811.
[2] Total differs from inventory figure at the end of fiscal year 1975 due to agencies' year-end adjustments.

TABLE 6.—ALL AGENCIES—WORLDWIDE FEDERALLY OWNED MOTOR VEHICLES, BY CLASSIFICATION INVENTORY AS OF JUNE 30, 1976

[Number of vehicles]

Department or agency	Sedans	Station wagons	Total sedans and station wagons	Ambulances	Buses, 11 or more passengers	Trucks and truck tractors—by gross vehicle weight: Less than 12,500 (1 ton and under) 4 × 2	Less than 12,500 (1 ton and under) 4 × 4	12,500 to 16,999 (1½ to 2½ tons)	17,000 and over (3 tons and over)	Total
LEGISLATIVE BRANCH										
Government Printing Office	1	6	7		1	40		4	17	69
Library of Congress	1		1		1					2
EXECUTIVE BRANCH										
Departments:										
State	798	183	981		[1] 16	765	(2)	91	72	1,925
Treasury	4,702	176	4,878		1	423	89	25	5	5,421
Justice	7,758	208	7,966	3	92	1,194	500	142	64	9,961
Interior	1,174	503	1,677	8	238	4,854	2,347	1,158	1,490	11,772
Agriculture	3,634	614	4,248		151	20,425	2,720	565	690	28,799
Commerce	26	15	41	2		323	90	54	53	563
Labor	168	147	315	13	259	732	135	170	133	1,757
Health, Education, and Welfare	46	28	74	9	10	108	64	71	70	406
Transportation	38	31	69	14	7	403	213	85	223	[3] 1,014
ACTION	27	267	294		13	93	115	5	1	521
Agency for International Development	239	126	365		7	215	211	39	15	852
American Battle Monuments Commission	10	2	12			35	3	13		63
Canal Zone Government	38		38	8						46
Community Services Administration	7	2	9			1		1		11

Energy Research and Development Administration	1,724	185	1,909	55	302	5,824	618	242	763	9,713
Federal Communications Commission	5	4	9			51		6		66
General Services Administration	42,648	4,477	47,125	279	1,473	21,587	5,489	1,111	1,436	78,500
International Boundary and Water Commission						1	2	5	12	20
National Aeronautics and Space Administration	74	62	136	13	8	760	63	104	92	1,176
National Gallery of Art		1	1			1				2
Nuclear Regulatory Commission	1		1				4			5
Panama Canal Company	54	8	62		40	502	35	35	83	757
Railroad Retirement Board	1		1							1
Smithsonian Institution	4	20	24			61	9	11	10	115
Tennessee Valley Authority	942		942	13	7	1,527	353	120	373	3,335
United States Information Agency	170	97	267		12	473	54	3		809
United States Soldiers' and Airmen's Home	8	1	9	[4] 3	4	21			6	43
Veterans' Administration	104	12	116	3	33	137	30	119	8	446
Total—Civilian agencies	64,402	7,175	71,577	423	2,675	60,556	13,144	4,179	5,616	158,170
United States Postal Service	1,359	(5)	1,359	(5)	(5)	114,977	176	1,511	3,397	121,420
Department of Defense:										
Army	13,565	1,362	14,927	1,219	3,901	25,598	(6)	1,438	9,376	59,459
Navy	3,852	1,451	5,303	651	1,505	21,601	(6)	3,509	3,682	36,251
Air Force	2,208	1,484	3,692	997	2,504	25,355	(6)	5,110	2,466	40,124
Civil Works, Corps of Engineers	768	70	838	4	11	4,149	(6)	561	220	5,783
Cemeterial Expenses, Army	5	2	7	2	2	45	(6)			56
Defense agencies	1,954	179	2,133	13	65	1,147	(6)	420	185	3,963
Total—Military agencies	22,352	4,548	26,900	2,886	7,988	80,895		11,038	15,929	145,636
Total—All agencies	88,113	11,723	99,836	3,309	10,663	256,428	13,320	16,728	24,942	425,226

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[1] Includes ambulances.

[2] Foreign 4 x 4 trucks included in 4 x 2 trucks.

[3] Training vehicles, omitted in the fiscal year 1975 report, are included for fiscal year 1976.

[4] 1 vehicle is a hearse.

[5] These types not separated in USPS data system.

[6] Included in 4 x 2 trucks.

TABLE 7A.—ALL AGENCIES—WORLDWIDE FEDERALLY OWNED PASSENGER CARRYING MOTOR VEHICLES (EXCLUDES BUSES AND AMBULANCES) INVENTORY CHANGES JULY 1, 1975 TO JUNE 30, 1976

[Number of vehicles]

Department or agency	Fiscal year 1976			
	Vehicles on hand beginning of year	Acquisitions	Dispositions	Net change during year
LEGISLATIVE BRANCH				
Government Printing Office	8	1	2	−1
EXECUTIVE BRANCH				
Departments:				
State	900	310	229	+81
Treasury	[1] 4,451	[1] 1,380	[1] 953	+427
Justice	7,905	2,179	2,118	+61
Interior	1,617	364	304	+60
Agriculture	3,996	760	508	+252
Commerce	46	3	8	−5
Health, Education, and Welfare	67	17	10	+7
Transportation	78	16	25	−9
ACTION	282	51	39	+12
Agency for International Development	387	86	108	−22
American Battle Monuments Commission	11	1		+1
Canal Zone Government	38	14	14	
Community Services Administration	10	3	4	−1
Energy Research and Development Administration	1,919	251	262	−11
Federal Communications Commission	7	2		+2
General Services Administration	40,977	10,034	3,886	+6,148
National Aeronautics and Space Administration	133	21	18	+3
Panama Canal Company	62	9	9	
Smithsonian Institution	21	6	3	+3
Tennessee Valley Authority	942	235	235	
United States Information Agency	220	82	35	+47
United States Soldiers' and Airmen's Home	9	[2] 1	1	
Veterans' Administration	70	41	2	+39
Total—Civilian agencies	64,156	15,867	8,773	+7,094
United States Postal Service	1,191	181	13	+168
Department of Defense:				
Army	15,481	1,885	2,439	−554
Navy	5,368	702	767	−65
Air Force	5,013	76	1,397	−1,321
Cemeterial Expenses, Army	7	3	3	
Defense agencies	2,310	441	618	−177
Total—Military agencies	28,179	3,107	5,224	−2,117
Total—All agencies	93,526	19,155	14,010	+5,145

[1] Acquisitions include seized vehicles. Dispositions include excessed and donated vehicles.

[2] Acquired as excess property.

ABLE 7B.—ALL AGENCIES—WORLDWIDE FEDERALLY OWNED BUSES, AMBULANCES, AND TRUCKS INVENTORY CHANGES JULY 1, 1975 TO JUNE 30, 1976

[Number of vehicles]

Department or agency	Fiscal year 1976			
	Vehicles on hand beginning of year	Acquisitions	Dispositions	Net change during year
LEGISLATIVE BRANCH				
overnment Printing Office	51	13	2	+11
ibrary of Congress		1		+1
EXECUTIVE BRANCH				
epartments:				
State	882	205	143	+62
Treasury	[1] 456	[1] 181	[1] 94	+87
Justice	1,710	450	165	+285
Interior	9,984	1,377	1,266	+111
Agriculture	25,492	2,205	3,146	−941
Commerce	557	44	79	−35
Health, Education, and Welfare	333	21	22	−1
Transportation	962	134	151	−17
ction	234	29	36	−7
gency for International Development	487	115	115	
merican Battle Monuments Commission	52	3	4	−1
anal Zone Government	9		1	−1
nergy Research and Development Administration	7,479	856	531	−325
ederal Communications Commission	61	6	10	−4
eneral Services Administration	31,125	2,208	1,958	+250
ational Aeronautics and Space Administration	1,065	103	128	−25
anama Canal Company	693	91	89	+2
mithsonian Institution	85	21	15	+6
ennessee Valley Authority	2,200	374	201	+173
nited States Information Agency	601	65	124	−59
nited States Soldiers' and Airmen's Home	33	[2] 1		+1
eterans' Administration	262	48	12	+36
Total—Civilian agencies	84,813	8,551	8,292	+259
nited States Postal Service	113,942	16,266	10,147	+6,119
epartment of Defense:				
Army	50,456	4,490	10,414	−5,924
Navy	31,473	2,091	2,616	−525
Air Force	38,149	8,276	9,993	−7,717
Civil Works, Corps of Engineers	5,285	175	515	−340
Cemeterial Expenses, Army	47	6	4	+2
Defense agencies	1,884	210	264	−54
Total—Military agencies	127,294	15,249	23,806	−8,558
Total—All agencies	236,049	40,065	42,245	−2,180

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[1] Acquisitions include seized vehicles. Dispositions include excessed and donated vehicles.
[2] Acquired as excess property.

TABLE 19.—LARGE FLEETS—DOMESTIC FEDERALLY OWNED MOTOR VEHICLES, BY CLASSIFICATION, GALLONS OF FUEL CONSUMED AND AVERAGE MILES PER GALLON, JULY 1, 1975 TO JUNE 30, 1976

Department or agency	Sedans	Station wagons	Ambulances	Buses, 11 or more passengers	Truck and truck tractors—by gross vehicle weight				Total
					Less than 12,500 (1 ton and under)		12,500 to 16,999 (1½ to 2½ tons)	17,000 and over (3 tons and over)	
					4×2	4×4			
Department of Agriculture:									
Agricultural Research Service:									
Gallons	176,102	80,070		833	656,066	80,000	77,167	21,667	1,091,905
Average miles per gallon	16.0	14.3		3.6	12.2	9.3	6.0	4.8	
Animal and Plant Health Inspection Service:									
Gallons	747,952	7,440			1,254,679	46,949	13,077	23,875	2,093,990
Average miles per gallon	14.8	12.5			13.2	11.8	5.2	8.0	
Forest Service:									
Gallons	518,343	419,512		155,387	7,931,127	1,661,133	345,137	808,889	11,839,528
Average miles per gallon	16.0	14.4		6.6	11.6	10.1	6.8	4.3	
Soil Conservation Service:									
Gallons	1,288,347	23,028			4,766,014	159,060	1,625	1,923	6,239,997
Average miles per gallon	15.4	14.2			13.8	11.7	8.0	5.2	
Energy Research and Development Administration:									
Gallons	1,375,526	226,422	19,649	882,222	4,360,777	552,706	184,310	1,122,692	8,724,304
Average miles per gallon	13.3	10.9	5.7	6.3	10.3	8.5	5.8	5.2	
General Services Administration:									
Gallons	35,277,271	4,063,333	333,647	2,308,028	18,076,491	4,952,887	976,429	2,132,791	68,120,877
Average miles per gallon	13.6	11.7	8.5	7.1	11.4	9.7	5.6	4.3	
Department of the Interior:									
Bureau of Indian Affairs:									
Gallons	445,044	2,735	10,000	216,286	495,686	87,176	78,197	291,346	1,626,470
Average miles per gallon	10.1	11.7	6.0	7.0	10.2	8.5	6.1	5.2	
Bureau of Sport Fisheries and Wildlife:									
Gallons	342,242	99,864		3,571	878,120	436,235	126,461	96,531	1,983,024
Average miles per gallon	14.0	14.7		7.0	11.7	8.5	6.5	4.9	
National Park Service:									
Gallons	545,281	177,569	1,081	41,795	704,876	213,333	170,000	243,273	2,097,208
Average miles per gallon	16.9	14.4	11.1	7.8	12.1	9.3	6.9	5.5	

Department of Justice:									
Federal Bureau of Investigation:									
Gallons	6,622,516	175,094	126	2,885	90,167	65,213	1,864		6,957,865
Average miles per gallon	11.1	10.6	15.9	5.2	12.0	9.4	5.9		
Immigration and Naturalization Service:									
Gallons	2,185,326			536,458	978,300	681,573	4,416	1,702	4,387,775
Average miles per gallon	10.6			4.8	10.0	8.9	7.7	4.7	
Tennessee Valley Authority:									
Gallons	987,728		3,171	3,896	1,440,943	371,818	144,565	642,449	3,594,570
Average miles per gallon	14.5		4.1	7.7	10.6	8.8	4.6	4.9	
Total—Civilian agencies:									
Gallons	50,511,678	5,275,067	367,674	4,151,361	41,633,264	9,308,083	2,123,248	5,387,138	118,757,513
Average miles per gallon	13.2	12.0	8.3	6.6	11.6	9.6	5.9	4.7	
U. S. Postal Service:									
Gallons	2,139,856	(1)	(1)	(1)	65,940,506	(1)	4,391,270	15,820,000	88,291,632
Average miles per gallon	13.9				7.9		6.3	5.0	
Department of Defense:									
Army:									
Gallons	4,646,033	673,162	477,667	2,734,068	14,022,970	(2)	609,531	5,441,475	28,604,906
Average miles per gallon	12.0	11.7	9.0	5.9	10.1		6.4	6.1	
Navy:									
Gallons	1,467,669	958,938	204,904	1,396,250	12,957,157	(2)	1,568,406	2,832,750	21,386,074
Average miles per gallon	13.3	11.3	10.4	5.6	10.2		6.9	4.0	
Air Force:									
Gallons	1,351,478	1,230,000	315,870	2,233,273	9,393,772	(2)	2,120,676	1,199,250	17,844,319
Average miles per gallon	12.0	10.7	9.2	5.5	16.7		7.4	4.0	
Marine Corps:									
Gallons	473,434	154,795		506,857	3,209,538	(2)	472,889	858,281	5,675,794
Average miles per gallon	16.6	14.6		7.0	13.0		9.0	6.4	
Civil Works, Corps of Engineers:									
Gallons	708,986	77,533	361	15,422	2,524,824	(2)	454,861	214,400	3,996,387
Average miles per gallon	14.8	15.0	8.3	8.3	17.0		7.2	5.0	
Total—Military agencies:									
Total gallons	8,647,600	3,094,428	998,802	6,885,870	42,108,261	(2)	5,226,363	10,546,156	77,507,480
Overall average miles per gallon	12.7	11.4	9.3	5.8	12.2		7.3	5.3	
Total—All large fleets:									
Total gallons	61,299,134	8,369,495	1,366,476	11,037,231	149,682,031	9,308,083	11,740,881	31,753,294	284,556,625
Overall average miles per gallon	13.2	11.8	9.1	6.1	10.1	9.6	6.7	5.0	

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[1] These vehicles not separated in USPS data system.
[2] Included in 4×2 trucks.

GLOSSARY

Acquisition.—For the purpose of this report, acquisition refers to a vehicle added to Government inventory through purchase.

Acquisition cost.—The initial vehicle purchase price paid by the Government.

Agency-held vehicle.—A Government-owned motor vehicle used by an agency which is responsible for its accountability, operation, maintenance, and disposal.

Assigned vehicle.—A vehicle assigned for more than 30 days to an individual or to an organizational element of the Government for essentially exclusive use. The using agency may "own" the vehicle, obtain it from an Interagency Motor Pool, or rent it from a commercial firm.

Consumer Price Index—Transportation.—An index published by the Bureau of Labor Statistics of the U.S. Department of Labor which measures average changes in prices of goods and services related to transportation.

Depreciation.—The decrease in a vehicle's worth due to age and/or mileage, normally calculated on a monthly or annual basis.

Direct cost.—The expenses which can be readily assigned to a specific vehicle or class of vehicles; e.g., materials and labor, contractual services, depreciation, and accident costs.

Dispatch vehicle.—A vehicle rented for short-term use, not exceeding 30 days, usually on a day-to-day or trip basis (generally associated with Interagency Motor Pool System vehicles).

Disposal.—Removal of a vehicle from Government inventory, usually by sale.

Holding agency.—A Federal agency having accountability for Government-owned motor vehicles. This term applies when a Federal agency has authority to take possession of, assign, or reassign the vehicle regardless of which agency is using the vehicle.

Indirect cost.—The expenses which cannot be readily assigned to a specific vehicle or class of vehicles because they are incurred in connection with the operation as a whole; e.g., indirect labor, administrative and fiscal services, rent, amortization, utilities, shop equipment depreciation, and tools.

Large fleet.—A fleet of 2,000 or more reportable vehicles, worldwide, for which accountability is held by a department or independent establishment or a bureau or comparable organizational unit of that department or independent establishment.

Lease.—Rental of vehicles by agencies from commercial firms, in lieu of Government ownership, for a period of 60 days or more.

POV.—Privately owned (employee's) vehicle used on official Government business for which use the employee is reimbursed by the Government on the basis of mileage.

Reportable vehicles.—All automobiles, station wagons, ambulances, buses, carryalls, trucks, and truck tractors. Excluded are semitrailers, trailers, and other trailing equipment such as portable wheeled air compressors, trucks with permanently mounted equipment, firetrucks, motorcycles, and military design motor vehicles.

Sedan types.—Sedans are categorized by type according to curb weight and wheel base. See Federal Specification KKK-A-811.

Utilization.—A term used for the measurement of a vehicle's usage, usually expressed in miles per vehicle year.

Vehicle-years.—A term used to reflect the equivalent total years of operation of an agency's fleet. It is calculated by adding the months of actual operation of all vehicles (or vehicles of a specific type) and by dividing the total by 12.

APPLICATION OF SOLAR TECHNOLOGY TO TODAY'S ENERGY NEEDS

(Congress of the United States, Office of Technology Assessment)
June 1977 (Excerpts)

Issue 3: Can Purchases of Solar Equipment for Federal Buildings Be Used To Stimulate the Solar Industry?

Yes. A major program for installing solar equipment on Federal buildings could be one of the Government's most powerful tools for encouraging the development of mass production of solar equipment by private industry.

Consider the following:

The Federal Government owns or leases approximately 446,000 buildings in the United States, with a combined floor area of nearly 3 billion square feet and spends almost $1.7 billion annually to heat and cool them. (That figure is expected to reach $1.9 billion by the end of the year, and about $3.5 billion by 1985.) If 10 percent of the present heating/cooling costs were capitalized—used for debt payments for the purchase of solar equipment—the Government could purchase nearly 100 million square feet of solar collectors annually.*

The Federal Government subsidizes operating expenses, including heating and cooling costs, of a large number of projects built with Federal assistance. The Department of Housing and Urban Development alone is paying more than $575 million this year to the nearly 1 million units of public housing administered by subsidized local housing authorities. If this were capitalized—again on a 10 percent basis—the Government could support the purchase of nearly 30 million square feet of collectors annually.

It would be difficult for the Government to encourage private concerns to install solar equipment if it is not using solar equipment on its own buildings.

In spite of the enormous potential, Federal programs for purchase of solar equipment have been proceeding quite slowly, largely because of concern about the cost effectiveness of solar devices. This concern is often magnified by the inability of program administrators to accurately evaluate the costs of solar techniques. In some cases, required formulas for determining the worth of a Federal investment (i.e., fixed limits on building costs, and present value computations with high discount rates) have inhibited these programs.

The opportunity to use Federal buildings for experimental energy equipment raises two difficult questions:

(a) What should the government use as a "discount rate" to evaluate alternative investments?

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*Assuming $20 per square foot for an installed system.

There is a considerable amount of disagreement among analysts on this point. Some argue that the government should make decisions with the same expectations of return as private investors. This view was formalized in a ruling by a previous administration which held that the government should only invest in equipment which would result in a 10% return on investment since this rate "represents an estimate of the average rate of return on private investment before taxes and after inflation." [1] Others argue, however, that the free market does not necessarily accurately assess the social costs of investments and that the Federal Government should therefore use investment criteria which better reflect social costs. Even if this basic principle is accepted, however, it becomes extremely difficult to determine what economic expectations are proper. Investments must be assigned values based on concerns about the environment, social costs, benefits to labor, benefits to national security and the stability of resource supplies, and other criteria difficult to evaluate in conventional economic terms.

When the government makes an investment that pays less than the return which could be realized if invested in the free market, society is losing some of the value of that capital. This of course means that society is subsidizing the investment in some way. The exact amount of this subsidy, however, can be as difficult to quantify as the value society might realize from the investment.

Nonetheless, several discount rates can be used to evaluate Federal equipment purchases:

(1) Ten-percent rate of return after taxes and before inflation: this technique would result in Federal investments in solar equipment which neither lead nor lag investments made by private industry.

(2) Use of a rate of return equal to the rate of the growth rate of the U.S. GNP: this would encourage Federal purchases of solar equipment and ensure that funds extracted from the economy by the Government were not affecting overall economic growth. (This would imply a discount rate of 2 to 5 percent.)

(3) Require only that the Federal Government recapture its initial investment without earning a return on the funds: this would obviously be a stronger stimulus to Federal purchase of the equipment. (Zero percent discount rate.)

The effect of applying different Federal discount rates to prospective Federal investments is illustrated in figure III–B–8; the anticipated effects of three separate discount rates on Federal decisions to purchase energy equipment are shown in figure III–B–9.

(b) If it is determined that the Government should subsidize the market in novel energy equipment, how should it select equipment?

If it is assumed that the Government will purchase equipment which cannot be justified in traditional economic terms, values other than those used by the free market must be applied. This is a perilous undertaking since it runs the risk that the bureaucracy will select equipment which would not have been chosen by the market if it had been given time to develop along traditional lines. In extreme cases, mistakes might actually result in slowing the rate at which solar equipment enters the market if the Federal stimulus results in accelerating the installation of less desirable devices, thereby diminishing interest in promising alternatives. At a minimum, any Federal procurement program must be carefully integrated with an overall plan to promote a market for solar equipment as discussed in the chapter reviewing overall policy alternatives.

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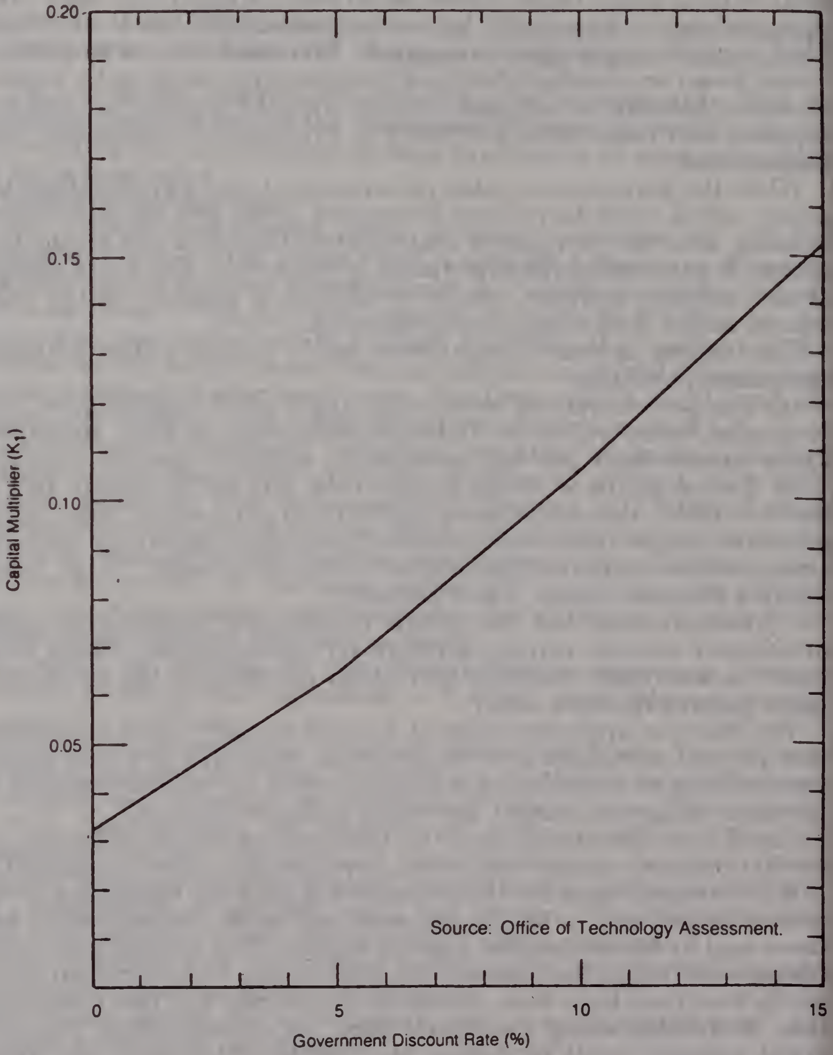
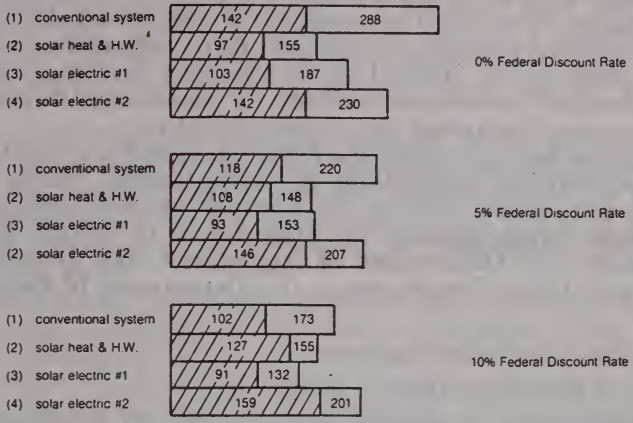
[1] Shultz, George P., "Discount Rates To Be Used in Evaluating Time-Distributed Costs and Benefits," OMB Circular A–94, March 27, 1972.

FIGURE III–B–8.—The effective cost of capital to the Government as a function of the discount rate used in decisionmaking. (Assumptions methodology used in preparing this figure are discussed in detail in the chapter on "Analytical Methods.")



Source: Office of Technology Assessment.

FIGURE III-B-9.—The effect of Federal discount rate on the perceived cost of Federal investments in three types of solar installations (in $/month/unit in a 196-unit highrise apartment).



Source: Office of Technology Assessment.

Assumptions:

(1) conventional system is an all electric heating & cooling & hot water system using a two-pipe distribution system, central chilling units, and resistance heating elements in each unit.

(2) solar heating and hot water system uses 4100 m^2 of flat plate collectors which cost 196 $\$/m^2$ installed (near-term prices), and 1.2 million kwh low temperature thermal storage (seasonal) in underground tanks.

(3) solar electric #1 uses 2500 m^2 of two axis tracking collectors with GaAs photovoltaic cells. The collectors cost 102 $\$/m^2$ installed including cells (an optimistic estimate of future prices), 10000 kwh of low temperature thermal storage, no batteries are used.

(4) solar electric #2 uses 4263 m^2 of one-axis tracking collectors with silicon photovoltaic cells. The collectors cost 300 $\$/m^2$ including the cost of the 15000 $/peak kw), the system has 17000 kwh of low temperature thermal storage and no batteries.

▨ assumes 1976 startup costs and electric prices increasing along BNL forecasts.

☐ assumes that electric prices increase by a factor of 5 over 60+ years (in constant dollars).

Source: Office of Technology Assessment

Solar-energy and Federal buildings: The current program

The Energy Research and Development Administration's (ERDA) intention to demonstrate solar equipment on Federal buildings in order to "develop initial market volume" and "expedite early demonstrations and provide additional early markets for developing industry," was announced in ERDA–23a.[1]

The Federal Energy Administration's (FEA) intention to make a major effort to assess the applicability of solar energy to Federal buildings was stated in ERDA–49. The MITRE Corporation was contracted to outline the procedures which should be taken to implement the program, and an implementation plan was submitted to the Energy Resources Council last July.[2]

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[1] ERDA–23a, pp. 15–40.

The MITRE Corporation report only outlined a series of decisions which would have to be made before a demonstration program could be undertaken. However, the report did reveal substantial opposition to an accelerated program on the part of representatives of Federal agencies likely to be affected. It is apparent that the small FEA program has had considerable difficulty in persuading OMB to undertake a major demonstration plan in the near future.

Mechanisms for implementing a Federal building program have been established through memoranda of understanding among ERDA, FEA, the U.S. Postal Service, the General Services Administration, the Veterans Administration, the Department of Health, Education and Welfare, the Department of Agriculture, the Department of Housing and Urban Development, the Department of Defense, and NASA.

The Potential of Individual Agencies

(1) Department of Defense (DOD)

The Department of Defense operates 380,000 buildings with a total floor space of 2.5 billion square feet.[3] This includes 260,000 units of family housing in the United States. It recognizes that energy costs are becoming a major burden and a program is now underway to install a variety of solar-equipment designs on several typical DOD building types. Some of the projects are funded by ERDA, some are funded internally. The projects include:

—Shopping centers at Kirkland and Randolph Air Force Bases (heat and cool).
—Administration building at Fort Hood (heat and cool).
—High temperature water from concentrating collectors at Fort Carson, Colorado.
—132 residential units on 16 Air Force, Navy, and Army bases (heat).
—Three Army Reserve centers (heat and cool).
—50,000 square feet of classroom at Fort Huachuca, Arizona.
—Air Force Academy housing (heat and cool, funded by USAF).
—Refrigeration at the Navy regional medical center at Orlando, Florida.

According to a study conducted for DOD by the BDM Corporation, solar photovoltaic cells can compete with many generating devices now used to provide electricity to remote sites. (Standard DOD techniques were used to measure cost-effectiveness.) The study estimated that DOD could purchase over $100 million of silicon solar cells annually without subsidy if the current price of cells dropped by about 50 percent.[5] DOD is also testing the applicability of solar power in several new DOD construction projects and indications are that the results, if promising, will be phased quickly into other DOD construction and modernization projects.

Potential retrofit investment are estimated by DOD to require 5- to 10-year payback times.

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[2] "Solar Energy Government Buildings Project, Draft Guidelines and Draft Implementation Plan," MITRE Corporation, March 26. 1976.

[3] ERDA 76–6, pp. 71, 75.

[5] "DOD Photovoltaic Energy Conversion Systems Market Inventory and Analysis," prepared for DOD and FEA, Spring 1977.

(2) Veterans Administration (VA)

Several solar projects have been proposed in the VA's 5-year plan:

Retrofit of the San Diego VA Hospital for heating and cooling; a solar-assisted heat pump for a new VA hospital to be built in Palo Alto, Calif; solar hot water systems for three new hospitals under construction; and 20 other projects are in the design stage for fiscal year 1977; 40 more are in the preliminary design stage for fiscal year 1978.

The VA's 171 hospitals are built, operated, and maintained by the VA itself, rather than by the General Services Administration (GSA), which is responsible for acquisition and maintenance of the VA's non-hospital facilities (these will be discussed under the GSA program). Fuel expenditures for the 171 VA hospitals amounted to $23.5 million in fiscal year 1975.

VA officials have informally indicated that the agency's hospital system could accommodate 120 solar installations, given a 2-year design-to-installation cycle, at a cost of some $32 million. They estimate that retrofit would save $1.6 million annually in fuel costs and that this saving could be diverted into a principal/interest debt repayment fund for the solar equipment.[6] To accomplish this, the VA's five-year Energy Plan would have to be revised. But apparently no legislation nor additional funding would be required.

(3) U.S. Postal Service (USPS)

A recent FEA-sponsored study found that USPS "owns or operates approximately 75 million square feet of floor space in 36,000 buildings." Of this floor space, approximately 90 percent is concentrated in 750 buildings.[7]

The USPS has two solar demonstrations underway: a new post office building under construction in Ridley Park, Pa., and a retrofit project in Boulder, Colo., which is just entering the bidding stage. A study is being made of the possibility of designing solar equipment for a standardized building design which the USPS could use in many parts of the country.

The USPS leases more than 80 percent of its buildings from the private sector, and the agency has the legislative authority and administrative flexibility to work any kind of variation on utility payment responsibility. At present, however, it has no positive program for promoting the use of solar power in its leasing program. The agency has not developed a comparative cost analysis system, but USPS officials feel that regional USPS personnel are professionally competent, as well as definitely inclined, to solicit solar as part of its leasing program if encouraged to do so.

(4) General Services Administration (GSA)

The General Services Administration has jurisdiction over all Federal office space with the exception of post offices, DOD facilities, VA hospitals, and certain other specialized facilities. It is now installing solar equipment on only two Federal buildings—one in Saginaw, Mich., the other in Manchester, N.H. Planned projects include:

(1) Heating and cooling facilities in a new Border Patrol building at Marfa, Tex.

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[6] Clark Granninger, VA.

[7] Solar Energy Government Buildings Project, MITRE Corporation, p. 4.

(2) Heating and cooling facilities at Federal office buildings in Denver, Colo., and Carbondale, Ill.

(3) Solar heating and cooling facilities at a Forest Service building in Arizona.

(4) Regional GSA administrators are soon to make recommendations for solar energy projects for one or two GSA buildings in each region of the country.

GSA's ability to install solar equipment is limited by the fact that it has leased a large number of buildings in recent years. The landlord is generally responsible for the payment of utility costs. If the use of solar energy were to result in lower utility costs than those programmed in a GSA comparative cost analysis, the landlord could pocket the savings, thereby increasing the attractiveness of solar utilization. On the other hand, should fuel costs be higher than the amounts programmed in the analysis, GSA would have to pick up these extra operating costs. Therefore, if GSA were to greatly emphasize solar energy in its solicitations for leasing or building new stuctures, there would have to be an expressed Congressional intent to provide year-to-year appropriations sufficient to cover possible energy cost overruns.

(5) *Health, Education, and Welfare* (*HEW*)

The Department of Health. Education, and Welfare is charged with demonstrating solar heating and cooling in Federal and private hospitals and other health-care facilities as part of ERDA's commercial demonstration program. An interagency agreement between ERDA and HEW authorizes HEW to solicit proposals for such projects, as of March 1977. It calls for an "open" solicitation; that is, solar contractors are to be invited to make proposals for heating and cooling demonstrations at certain health care facilities. Five or six projects are anticipated under the proposal, and about $1 million in ERDA funds is involved.

In addition, ERDA has funded a $300,000 project for solar installations at an Indian health-care facility in New Mexico and at a Public Health Service Hospital yet to be chosen. Bids are expected to be awarded in August or September.[9]

The proposed National Energy Act would provide $100 million for the installation of solar heating and cooling systems in Federal buildings through 1980 (this should be adequate to support systems on 50 to 150 large buildings).[10] The Act places responsibility for determining both the types of equipment to be demonstrated and the buildings used for demonstration in the hands of individual agencies, with FEA (or its successor) given final selection authority. The Act explicitly excludes the use of Federal buildings for demonstrating solar devices capable of generating electricity, pumping or desalinating water, providing direct mechanical drive, or any purpose other than direct heating and cooling.

II. BUILDINGS OPERATED FULLY, OR IN PART, UNDER REGULATIONS ESTABLISHED BY THE FEDERAL GOVERNMENT

The Federal Government, in addition to the buildings it owns or leases, supervises the operation of many buildings that receive Federal loans or operating subsidies. The Government could use its leverage to encourage the use of solar-energy equipment on such projects. In the case of buildings which receive operating subsidies partially attributable to energy costs, the Government might directly benefit from diverting annual subsidy funds to programs designed to capitalize solar devices.

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[9] Carl Conner, ERDA, private communication.

[10] Title I, Part F, subpart 3.

The largest number of federally sponsored residential units have been constructed under public housing programs. Over 1 million units of low-cost housing have been constructed with federally subsidized municipal bonds since 1937. Projects covered under Section 8 of the Housing Act also receive annual payments to insure that tenants are charged no more than 15 to 25 percent of their annual income for rent. Approximately $575 million will be spent by HUD for these subsidies during fiscal year 1977.

Unfortunately, current accounting procedures make it difficult to determine the fraction of annual subsidies attributable to energy costs. HUD officials estimate that energy costs currently account for 20 to 30 percent of the subsidy payments.

Public housing

The Public Housing Program has funds for modernizing existing structures (the approximately $20 million available in fiscal year 1977 was capitalized by local developers into about $200 million in project funding). Energy conservation is considered a major objective of recent modernization investments. However, there are only weak incentives for local housing modernization investments; HUD has no program-wide conservation goals. There are no real incentives for local housing officials to invest in conservation equipment, largely for the following reasons:

(a) There is a general feeling that the Federal Government will have to continue to subsidize energy costs, and local officials therefore apply all available funds to other modernization projects.

(b) There is much less glamor in retrofitting older establishments with conservation equipment than in overseeing innovative new projects. The effectiveness of area personnel tends to be judged on the basis of their performance on newer projects.

Until late 1974 HUD's legal staff had ruled that operating subsidies for public housing could not be used to capitalize investments in energy-conservation equipment. A recent ruling has changed that opinion, and there are now judged to be no legal barriers to using operating funds for solar and other energy equipment. However, there has been little attempt to use operating funds for solar equipment, since HUD officials are skeptical that solar devices could be economically attractive on their projects without additional Federal subsidies.

Required housing

In addition to public housing, the Federal Government acquires a substantial number of residential units because of foreclosures on VA, FHA, and FmHA loans (HUD currently owns approximately 90,000 such units). The current policy is simply to dispose of this property as rapidly as possible without making modifications to the structures. It might be desirable, however, to require that the Federal Government provide certain of these houses with energy-conserving equipment before they are resold.

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ISSUE 7: WHAT ARE THE MAIN PROBLEMS IN GAINING WIDER ACCEPTANCE FOR SOLAR TECHNOLOGY AND WHAT CAN BE DONE TO SOLVE THEM?

The central problem, not surprisingly, is the novelty of the equipment. Homeowners, builders, architects, and the financial industry share these fears: (1) Will the system work as advertised? (2) How long will it last? (3) Will operational costs be prohibitive? (4) Will a solar unit hurt the resale value of property in which it is installed? (5) Will the technology change so rapidly that the equipment now available will soon be obsolete?

These anxieties are intensified because: (a) there are no standard techniques for presenting performance data on the variety of different systems for sale, and (b) many systems are offered by small organizations without substantial assets or wide experience in manufacturing. Indeed, many of the firms now producing solar collectors, for example, are likely to vanish during the next 10 years, leaving their customers with equipment no one else is qualified to repair. That part of the problem will get even worse because potential buyers will be faced with an ever-widening array of equipment and advertising claims.

To be sure, any new technology undergoes such growing pains. And in due course certain manufacturers will establish reputation for high-quality products and for backing their systems with attractive maintenance contracts. Unfortunately, it could take years for this to happen—and in the meantime some unscrupulous dealers are likely to enter the field.

Can the government help to remove most of these concerns? It will be extremely difficult the way things look now—the Government itself is uncertain about the best technical approaches to support, and it could not be dogmatic anyway. However, standards can be established for the equipment the Government buys, and this could provide some guidance for prospective purchasers. Even so, great care is needed to make sure that such standards do not inadvertently eliminate novel approaches. And it will not be an easy matter to work out standards for another reason: each sub-technology will require its own set of standards, which must be arranged in such a way that they are applicable to a variety of building sites. Some such work has already been done. The National Bureau of Standards has developed interim standards for solar heating and hot-water systems, and NASA-Lewis has developed preliminary standards for the photoelectric systems which will be purchased for electric generation.

The government could also help by requiring that all systems sold bear performance ratings conducted under procedures prescribed by Federal law. The necessary testing could be conducted by private laboratories. The government could assist in training staff members and in obtaining the equipment needed to perform the tests.

However, none of these approaches can eliminate the basic fear which surrounds a novel technology. The most powerful influence on the public's reaction to onsite equipment will be the behavior of the solar industry itself. Because of its strong self-interest in policing itself, it may well be the best source of advice for ways in which the government might assist in building consumer confidence.

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CHAPTER VII. THE IMPACTS OF ONSITE SOLAR ENERGY

Widespread utilization of the onsite solar energy devices discussed elsewhere in this paper could have a number of impacts in areas not easily measurable in the quantitative, economic, and technical terms which have dominated most of the discussion in this report. The discussion in the present chapter will evaluate potential impacts in the following areas: national security and world trade; and manpower requirements and the attractiveness of employment in solar energy-related fields.

VII.1 THE IMPACT OF SOLAR ENERGY ON U.S. SECURITY AND TRADE

Extensive worldwide development of solar energy systems would, in time, relieve some of the strain imposed on international stability by competition for energy resources. It could provide a reliable source of power not dependent upon imports, and the necessary technology would be accessible without requiring large numbers of highly trained engineers or foreign technicians to implement. Some components of sophisticated systems (i.e., photovoltaic devices or advanced heat engines) would need to be purchased and could provide a significant export market for U.S. equipment and licenses. In all probability, solar energy will be economically attractive in most other countries before it is competitive in the United States where energy is low cost—a large fraction of the value of solar energy is the value of the labor required for installing and manufacturing collectors and other relatively simple devices. Solar energy is expensive where labor is least inexpensive. The development of indigenous energy sources abroad should also reduce pressures to accelerate the development of nuclear power, and thereby reduce opportunities for the proliferation of the technology and materials required to develop nuclear weapons.

Development of a foreign market for solar energy devices could provide an excellent opportunity for U.S. exports, and the resultant expanded sales would probably lead to lowered costs and improved quality of domestic solar equipment. The international utilization and impact of solar energy may depend critically on U.S. activity in the area over the next few years. Research in this field in the United States has become the most advanced in the world, and many nations will look to the United States for guidance in this area. A U.S. commitment to solar power would encourage foreign commercialization of the technology, if only by giving it prestige.

1.1 International stability

Energy supply problems have moved rapidly to the top of public policy agendas around the world in recent years. Several issues are overriding. First, in the long term, perhaps 25 to 50 years from now, global oil and gas resources will have been nearly depleted. Industrial nations are using energy (primarily oil and gas) at rates which require expressing consumption in numbers that would impress even an astronomer; for instance, by itself, the United States consumed 74 quadrillion Btu's in 1976. While competition for the world's remaining energy resources can only intensify as less developed nations expand their industrial base and increase their per capita energy consumption, recent studies of world petroleum reserves predict that maximum physical extraction of oil will be approached by the early 1980's.

The severity of the long-term problem can be seen in figure VII–1. The world's total known recoverable energy reserves are 31×10^{18} Btu's (the equivalent of 1,300 billion tons of coal). Nearly half of this amount is found in the North American Continent (although this share would be considerably reduced if oil shale assests are overstated), with the rest of the world dividing the remaining reserve. If all other countries used energy at current U.S. consumption rates, this entire reserve could be consumed in 23 years. Looked at in another way, the reserve would be depleted in about 40 years if world energy demand continues to increase at the current rate of about 5 percent per year. Traditional energy sources will vanish with frightening speed even if estimates of world reserves are low by a factor or two.

FIGURE VII–1

WORLD ENERGY SUPPLY AND DEMAND—MEASURED WORLD RECOVERABLE ENERGY RESERVES, 1974

[Quadrillion Btu]

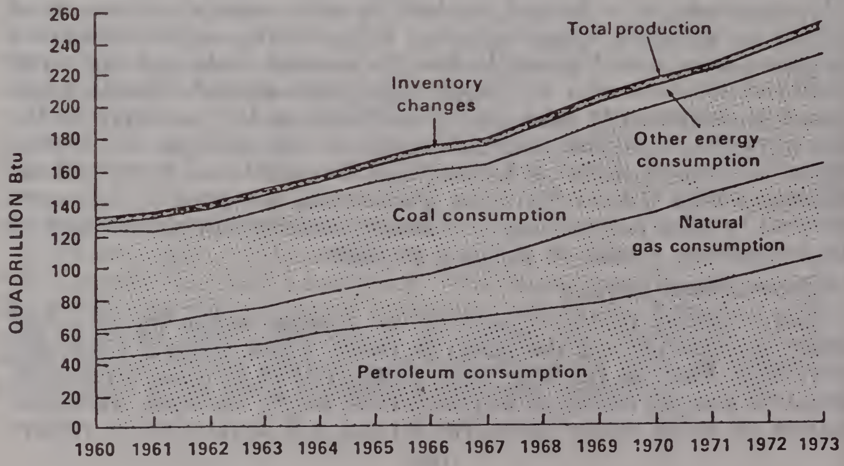
Area	solid fuels	Crude oil	Natural gas	Oil shale and tar sands[1]	Uranium (nonbreeder)[2]	Total
Africa	361.7	526.6	201.7	81.4	198.1	1,369.5
Asia (less U.S.S.R.)	2,608.7	2,202.4	432.6	870.2	3,1	6,126.0
Europe (less U.S.S.R.)	2,581.5	57.1	153.6	117.0	46.4	2,955.6
U.S.S.R	3,325.5	333,6	577.9	139.0	Unknown	>4,376.0
North America[3]	5,070.9	301.0	360.6	9,111.0	422.7	15,286.2
South America	49.8	311.5	60.6	23.7	11.9	457.5
Oceania	459.8	9.4	24.9	9.2	99.1	602.4
Total	14,457.9	3,741.2	1,831.9	10,351.5	>781.3	>31,173.2

[1] According to the U.S. Department of the Interior, Bureau of Mines, North American tar sands and shale oil reserves may be severely overstated. Development of most of these reserves is not economic at present.

[2] Energy content using breeders 60-100 times as great. Thorium resources neglected.

[3] U.S. reserves shown in more detail elsewhere.

Source: World Energy Conference. "Survey of Energy Resources" New York, 1974.



Source: "Energy Perspectives 2," U.S. Department of the Interior, June 1976, pp. 11 and 20.

WORLD ENERGY CONSUMPTION, PRODUCTION, AND INVENTORY CHANGES

It is unlikely, however, that production or consumption rates will continue to grow exponentially; production rates will be constrained by the producing countries for political and financial reasons as physical production limits are approached, and major efforts to conserve energy will almost certainly be made which could help a great deal to postpone the hour of reckoning. Nevertheless, a depletion of energy sources will eventually be reached and at that point most nations will have very few options. Although the United States is in an unusually favorable position because of its large indigenous coal resources, most nations will be compelled to turn to use of breeder reactor technology, possibly to fusion, or to the novel "renewable" energy sources, most of which make direct or indirect use of solar energy.

The second more immediate energy supply issue involves import dependence. Reliable sources of energy are essential to the survival of industrial societies and are critical to the aspirations of less developed nations. During the past decade, however, many nations have found indigenous sources of fossil fuels and hydroelectric power insufficient, requiring them to become increasingly dependent on imported fuels, principally oil. In some cases the extent of this dependence has become very large (as shown in table VII–1 and figure VII–2).

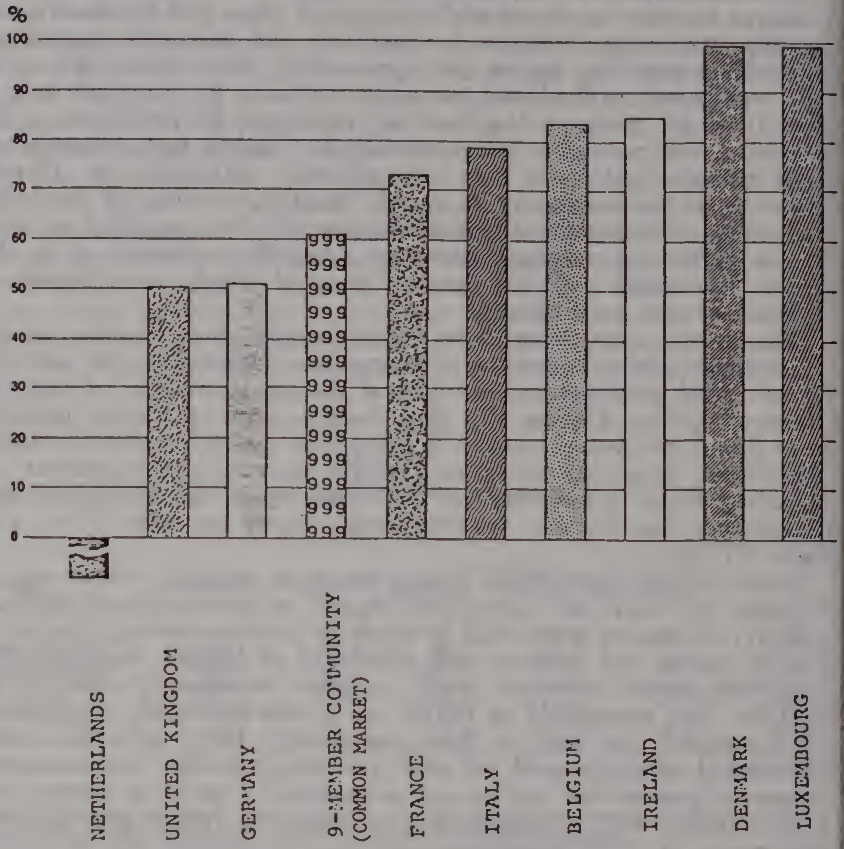
There can be little doubt that growing uncertainty about energy supplies will have an important impact on international political stability. Intensive efforts will be made to develop domestic resources and to insure the security and reliability of foreign supplies. The latter objective, however, would appear increasingly difficult to achieve. The emergence of OPEC as a near-monopoly supplier of oil illustrates that nations fortunate enough to be able to export substantial quantities of oil and gas recognize the political and economic power this implies. As a result, the price of energy has risen sharply and is occasionally adjusted to reflect the political preference of OPEC nations.

TABLE VII–1.—PERCENTAGE OF DOMESTIC ENERGY CONSUMPTION RESULTING FROM IMPORTS

	1974	1980
U.S.S.R.	(−32)	(−26)
Eastern Europe	77	83
Canada	(−16)	6
United States	16	22
Europe (ECD)	65	50
Japan	96	93
Australia/New Zealand	(−5)	8
Oil-importing developing nations	48	32
Do	(−58)	(−146)
OPEC	(−1, 188)	(−678)

Source: World Energy Outlook, Organization for Economic Cooperation and Development, Paris, 1977.

FIGURE VII-2.—Dependence of member of the European Community o energy imports.



Source: Quarterly Bulletin of Energy Statistics, EUROSTAT, 3–1976, p. 2.

The sense of insecurity attached to the importing of energy resource is magnified by the fact that in most cases supply lines for energy ar very long and thus potentially very vulnerable. No nation can b comfortable if a commodity on which its economy depends comes from so uncertain a source. Moreover, in any situation where a state or a group of states greatly dependent on imports can assemble a substantial military capability, a disruption or threatened disruption o those supplies carries with it a high risk of international violence. It i noteworthy that the U.S.' response to the embargo of 1973–74 included thinly veiled threats of military action.

Apart from the direct threat of military violence, uncertainty abou supplies and spiralling energy prices threaten to disrupt the stabilit of many weakened western economies and to dampen the hopes o nations aspiring to raise their standards of living. There has bee speculation, for example, that democratic institutions (in nations suc as Italy) may collapse under the weight of accelerating inflation and recession traceable, at least in part, to energy costs. Henry Kissinger has warned that:

> Not since the 1930's has the economic system of the world faced such a test. The disruptions of the oil prices rises, the threat of global inflation, the cycle of contraction of exports and protectionist restrictions, the massive shift in the world's financial flows and the likely concentration of invested surplus oil revenue in a few countries—all threaten to smother the once-proud dreams of universal progress with stagnation and despair.

A final potential source of energy-related conflict concerns nuclear proliferation. The global spread of civilian nuclear energy has been accompanied by a decline in the number of technological, economic, and time barriers to acquiring nuclear weapons. A substantial and increasing number of countries are already capable of producing their own nuclear arms. The consequences of proliferation are subject to debate, but they are unlikely to be positive from the perspective of U.S. or global interests. A strong argument can be made that proliferation will jeopardize regional and global stability, increase the likelihood of nuclear war, exacerbate the threat of nuclear-armed, nonstate terrorism, and greatly complicate U.S. relations with new (potential or actual) nuclear weapons states. Because security concerns are a key incentive to acquiring nuclear weapons, the probability of proliferation will tend to be greatest in regions with the highest potential for international conflict.

In the past, the United States placed major emphasis on aiding nuclear energy development programs around the world. In recent years, this program has been tempered by a concern about proliferation, resulting in efforts to tighten export agreements, to prohibit the export of facilities for reprocessing plutonium or enriching uranium, and to discourage foreign transfers of such technology. The United States, however, is in a weak position if it attempts to discourage the development of nuclear power in nations where attractive alternatives are not available.

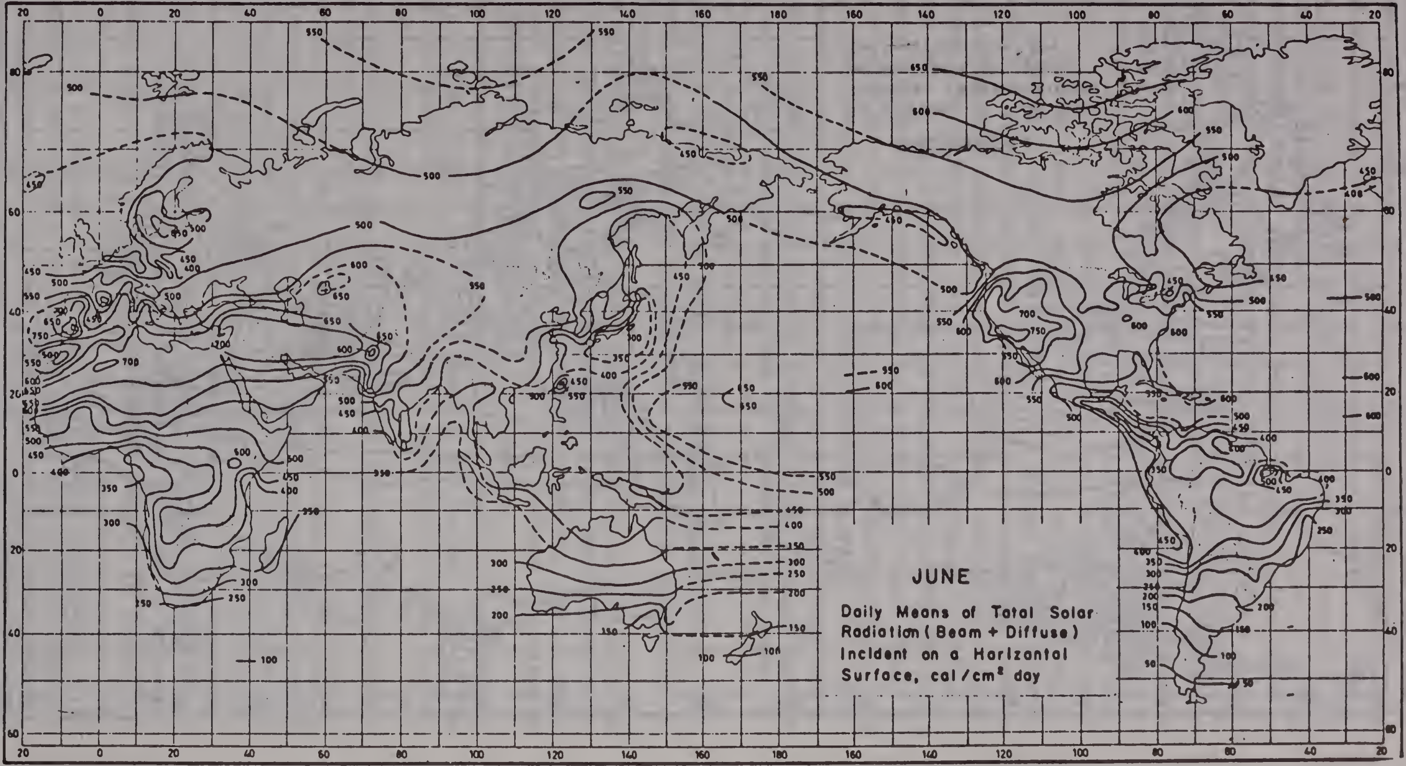
The international trends in energy outlined above, of course, have important implications for U.S. foreign policy. First of all, whatever affects international political equilibria also affects American foreign policy, which has had as its overriding objective the maintenance of global stability, for in recent years, stability has been viewed as a necessary precondition to the effective pursuit of other U.S. interests. Second, as the world's largest consumer and importer of energy and the acknowledged leader in most energy technologies, the United States will necessarily be the focus of international tensions generated by energy issues. Washington's relations with other industrialized countries (many of them U.S. allies) have already been strained by efforts to impose controls on nuclear exports and by a competitive scramble, following the 1973–74 embargo, to obtain reliable sources of oil imports. With the emergence of the United States as a major importer, petroleum has become a potentially serious source of division within the Atlantic Alliance. By contrast, Soviet capabilities to export oil and uranium have augmented Moscow's hold over its clients in Eastern Europe.

Its wealth and power have long made America the representative and symbol of the industrialized state in the eyes of less developed countries. Thus, inevitably, the United States has been the focus of Third World resentment, a condition exacerbated by the scale of U.S. energy consumption in an increasingly shortage-conscious world and by recent American efforts to constrain nuclear exports.

A danger exists that energy problems may serve to reinflame some of the anxieties and ambitions which formerly dominated relations between the Communist and non-Communist worlds. For example, there has been fear that the U.S.S.R. may successfully exploit the Arab-Israeli dispute to obtain influence over the disposition of Middle Eastern oil, upon which most of the industralized countries of the world are so dependent. Rising energy costs, in conjunction with population, food, and resource pressures, may also frustrate the development hopes of many Third World countries, thereby strengthening the hand of Communist movements in those countries and consequently putting new strains on the U.S.-Soviet and U.S.-Chinese relations.

Solar energy might play a major role in solving the global energy supply problem. It is difficult to anticipate the rate at which solar energy will be introduced into the world energy market—it is likely to play only a small role in the near future. Solar energy is, however, the one energy resource which is reliably available worldwide. To the extent that it can be substituted for conventional energy sources, solar energy could provide a number of nations with the confidence that needed energy would continue to be avialable in spite of uncertainties in worldwide energy markets. Other sections of this study have identified a number of circumstances under which solar energy could be competitive in the U.S. market, but this is a difficult test. Consumers in the United States pay some of the lowest energy prices in the world, and large U.S. coal resources have led many to believe that American energy prices will not rise dramatically in the foreseeable future. Moreover, figure VII–3 indicates that the United States does not enjoy a particularly favorable position with respect to the amount of sunlight it receives. All of this suggests that solar energy could be competitive in a number of nations well before it penetrates U.S. markets.

Daily Radiation for June


JUNE
Daily Means of Total Solar Radiation (Beam + Diffuse) Incident on a Horizontal Surface, cal/cm² day
20
0
20
40
60
80
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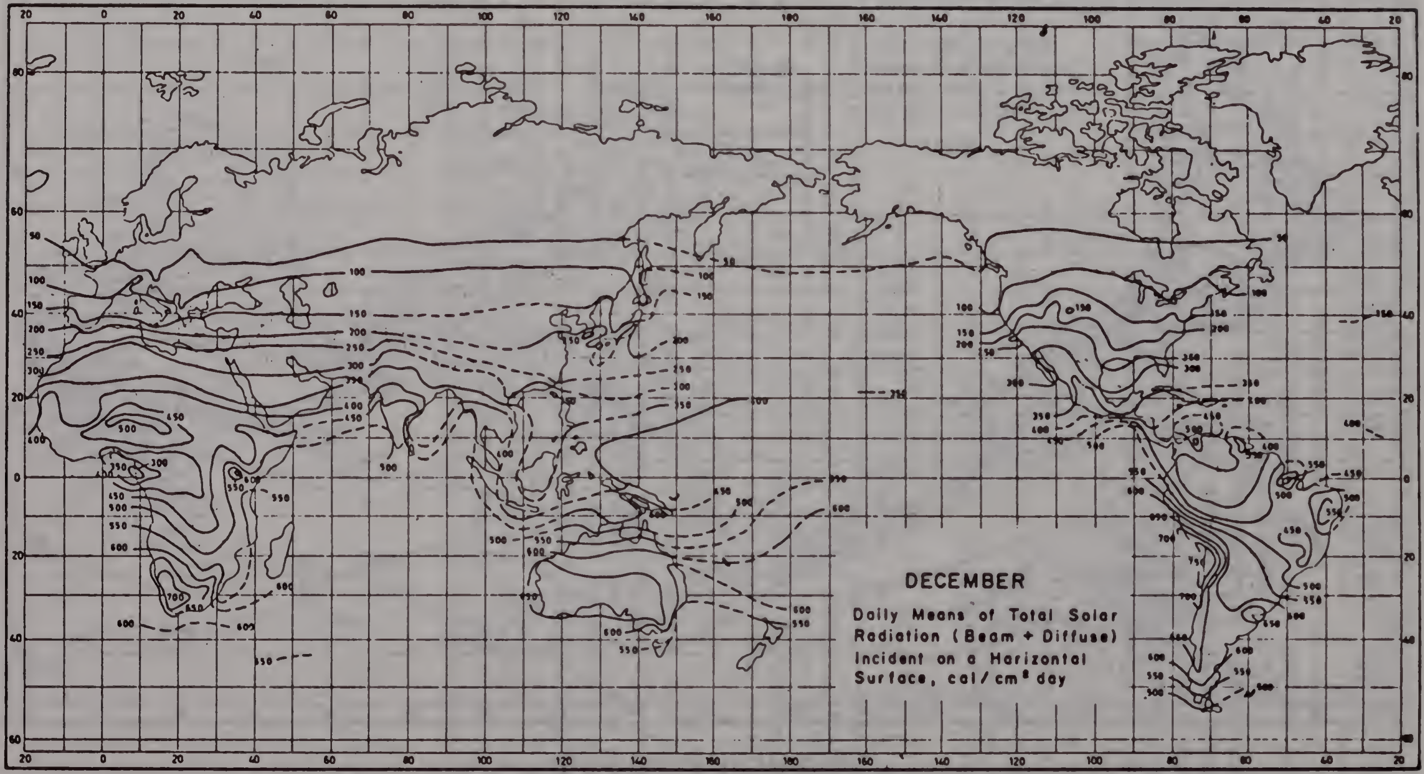

Daily Radiation for December

The worldwide development of solar energy technology has a number of potential impacts in terms of international politics. It might create an easing of the world global competition for imported oil, with a consequent softening of the world market price. It would provide a peaceful means for easing energy supply vulnerabilities. The demand for nuclear energy as an alternative to petroleum should diminish, permitting a more careful and systematic approach to the issue of whether to construct a national nuclear power industry. Increased reliance upon solar energy would reduce the pollution of the global environment produced by using fossil fuels (including air- and water-borne emissions, solid waste, heat, pollution resulting from increased oil tanker traffic, and damage to land surface from strip mining) and nuclear power generation (including radioactive wastes and heat). Although curbing the growth of a global nuclear energy industry will not in itself prevent proliferation—an aspiring nuclear weapons state can still construct facilities designed solely for weapons, e.g., a plutonium production reactor and a reprocessing plant—nevertheless, one of the major routes to proliferation, diversion from a commercial nuclear fuel cycle, will be largely foreclosed. Thus, if the previous analysis linking current trends in energy supply and demand to international political disequilibrium is valid, the emergence of solar energy could have an important stabilizing effect. This will be particularly true if solar energy fulfills its considerable promise as an energy source appropriate for developing countries.

1.2 Solar energy and developing nations

The relatively small onsite solar technologies examined in this report should be particularly attractive to developing nations for a variety of reasons:

1. These nations typically have not invested in an extensive network of transmission and distribution facilities (equipment which frequently costs as much as the generating stations themselves); onsite technologies could provide power to dispersed sites without the expense and delay associated with building such equipment.
2. Onsite equipment does not require an enormous investment of capital in a single project, thereby reducing the overall risk of the investment and avoiding expensive capital carrying charges during. construction.
3. The equipment can be built rapidly and produce power within weeks or months, instead of requiring years.
4. Major banks are likely to be interested in loans to developing countries for capital equipment which do not commit the borrowing nation to large operating expenses. Solar devices fall easily into this category, while generating equipment based on fossil fuels might not.
5. Generating capacity could be expanded flexibly and proportionately to meet growing requirements for energy. Large facilities produce sudden large increments in capacity which are difficult to manage. This problem frequently results in prolonged periods of expensive overcapacity.

Some of these advantages would be reduced or eliminated if it were necessary to construct a centralized utility large enough to meet all energy requirements of the area under the assumption that solar equipment might supply no energy during some period of peak demands. There are a number of ways of eliminating the need for centralized backup power in developing countries: (1) the facilities requiring energy could simply be shut down when energy was not available—this would reduce labor productivity but would not be as significant in a location where labor was relatively inexpensive; (2) many solar applications in remote areas, such as water pumping, will need no backup since storage is very inexpensive; (3) small emergency generating equipment could be maintained to provide backup power when solar energy fails. Energy from such sources is commonly used in remote villages and is very expensive, but the costs would be manageable if the devices were only operated a few days each year.

Solar energy should also be attractive to the less developed countries on grounds of broad social utility.

(a) As a relatively labor intensive means of power generation (both in terms of manufacture of components and installation), solar energy should help alleviate the endemic high unemployment and underemployment that plague most developing countries.

(b) Village siting of solar facilities would help raise rural living standards.

(c) With some exceptions, solar energy facilities can be constructed utilizing locally available materials (for the most part).

(d) Developing solar energy would not commit those countries to forms of energy production that they may not be able to sustain over the long term, either because of fuel shortages or the lack of secure funds for operating costs.

The potential utility of solar energy to developing countries must be assessed relative to other available energy sources. Most developing nations are located in the tropics—an area with an abundance of sunshine but, in general, a poor endowment of other energy resources. As previously noted, these countries have tended to rely on imported petroleum to fuel their ambitious programs for industrialization. Recent increases in the global market price of oil, however, have jeopardized this strategy. In Bangladesh, India, Pakistan, and Burma, for instance, badly needed irrigation pumps stand idle because those countries can no longer afford the costs of diesel fuel and the maintenance of the diesel motors.

A number of developing countries have already exhibited an interest in solar energy. It would appear that the inexpensiveness of electric power in the United States—ranging from a few cents to 10 cents a kilowatt hour—has misled U.S. officials and industry alike into thinking that solar energy is not cost competitive. In comparison, electricity in some parts of Senegal costs as much as 95 cents per kWh, although government subsidies reduce the selling price to 35 cents per kWh. A number of solar devices which could be produced in the next 2 to 3 years can provide electricity at a much lower cost. Cost-competitiveness or cost-benefit calculations, however, have no relevance to countries which have no alternatives. In an isolated jungle village, fo example, solar energy production might be the only practical way t provide power to irrigate crops or pump drinking water, even if th cost is exorbitant by U.S. standards.

Solar energy offers a promising avenue for improving U.S. relation with the Third World—an area in which Washington has not bee notably successful in recent years—because it is peculiarly adaptabl to the needs of the developing countries. Solar energy is particularly attractive in this regard because it offers a means of directly contributing to improved well-being at the village level. The days of the early Peace Corps aside, Americans have not been particularly adept at providing technology suited to the rural conditions, low skill levels and plentiful labor supplies which characterize the living conditions of much of the world's population. The Peace Corps analogy is suggestive. One might envision the creation of an "energy corps" of small, technologically competent teams as part of a U.S. aid program, assisting villagers in the installation of simple onsite solar facilities. All of this will serve to reinforce the U.S. global reputation for technological leadership and innovation. At a minimum, solar energy development would seem to offer the United States an opportunity to modify its present Third World image to closer identification with the aspirations of developing nations.

Solar energy also has substantial promise as an energy source for industrialized countries. Programs for the development and utilization of solar energy are long standing in Europe and Japan. (These are reviewed below.) Some of these countries can be expected to emerge as U.S. competitors in supplying the international solar energy market of the future.

1.3 Foreign trade in solar technologies

If solar energy can, in fact, provide a competitive source of energy in many parts of the world, the potential for U.S. exporters should be substantial. There have, however, been no detailed surveys of the extent of this market, either by the U.S. Government or by U.S. solar industries. Some observers are convinced that there is a potential market of many hundreds of million dollars in annual sales to underdeveloped nations alone, and see no reason why the United States cannot capture 80 percent to 90 percent of that market.

Other analysts are more conservative. They note the limited capability of poor countries to finance imports, and the fact that much solar energy hardware is so simple as to be unprotectable by patent. Moreover, low labor costs in developing countries and the expense of transporting bulky solar equipment suggest that many less developed countries will find solar energy an ideal import-substitution industry. It is not difficult to imagine a nation like Singapore, which has quickly mastered a variety of medium-level technologies, developing the capability to fabricate some solar equipment. If this assessment is correct, the U.S. export market may be limited to relatively high technology solar components, e.g., solar cells, electrical controls, and heat engines.

These projections will remain speculative until an overseas solar marketing survey is conducted to look at the energy needs of developing countries, the kinds of specialized solar technology that would be required to meet those needs, and the capability of the developing. countries to pay for imports or to manufacture their own equipment. This information would be analyzed in the context of existing U.S. technology, and would indicate both how extensive the market for off-the-shelf solar hardware is, and how existing technology could be adapted to provide the specialized equipment needed by other countries. A half dozen consulting firms have made unsolicited proposals to ERDA to conduct such a study, but the idea has not been acted upon as yet.

The development of a foreign market would also substantially benefit the domestic solar energy equipment market, since the additional overseas demand for solar facilities would result in larger production runs and more research. This should reduce domestic prices and accelerate improvements made in devices sold in the United States, yielding the United States a long-term advantage, even if developing nations began to produce their own systems in a decade or so. It is likely that foreign manufacturers would require U.S. assistance for some times they could, for example, utilize U.S. patents or licenses for solar devices.

Estimates of a large potential foreign market for solar energy are supported by recent studies conducted by the Department of State. One study, published in November 1976, indicated a substantial potential market for solar technologies in eight oil producing nations (Algeria, Indonesia, Iran, Iraq, Mexico, Nigeria, Saudi Arabi, and Venezuela). The study showed that although all eight countries preferred manufacturing solar equipment themselves rather than importing it, none was making a sufficient commitment to solar research to produce equipment which could compete with the small solar electric generating equipment and desalinization processes being developed in the United States. State Department studies have also indicated that a smaller but significant market for solar devices exists in other oil producing countries and in underdeveloped oil importing nations. This last group of countries, according to surveys, was anxious to develop all types of nonpetroleum energy sources and willing to devote a substantial amount of their capital if such sources prove economically and technically feasible.[1]

Some industrialized countries will develop their own solar energy industries and, as a result, will not constitute a significant market for U.S. exports. The exception may be certain high-technology components, principally solar cells.

1.4 *Foreign competition in solar technologies*

The U.S. Government, primarily through ERDA, spends approximately five times as much for solar energy research, development, and demonstration as all other foreign governments combined. Although other nations have begun to increase their financial commitment to solar research and development, their solar budgets are tiny compared to the $290.4 million FY 77 budget of the ERDA Division of Solar Energy.

Nevertheless, significant solar technologies have been developed in a number of other countries. Japan, Israel, and Australia produce more energy from the sun each year than the United States, primarily because of their longer involvement with simple hot-water and space-heating devices. France, Germany, Japan, and perhaps Israel sell more solar equipment abroad annually than the United States.

There are several reasons for this seeming anomaly. First, conventional energy in the United States has been, for the most part, plentiful and inexpensive; consequently, this nation has delayed emphasis on solar heating and hot water (except in Florida and Southern California during the 1940's and 1950's) while countries such as Japan, Israel, and Austrialia have been installing such devices for decades. Second, the United States spends proportionately more for research than other countries, with solar budgets, most of which stress currently marketable technologies. Private industry in most other countries has been more deeply involved in solar technology than has its U.S. counterpart, and it is private industry, not the Government, that usually determines an export market. Finally, the United States spreads its financial resources among a broad range of solar technologies; many other countries stress funding of fewer specialized projects, which lead to more rapid marketing of results.

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[1] Martin Prochnik, Office of Nuclear Energy and Energy Policies, Department of State, private communication, March 1977.

In the past year, France has doubled its solar budget to almost $10 million per year, putting special emphasis on developing 300 kW, 800 kW, and 3.5 MW solar electric systems; West Germany, which spends about $6 million per year, also increased its funding for solar energy substantially; Japan is spending about $5 million per year in its government-sponsored Project Sunshine; and Israel has boosted its solar commitment to about $2 million; Iran has extended its solar program, opening a 100-person solar institute; Saudi Arabia has created a similar center, although smaller, staffed by about 20 technologists; the Common Market has decided to build a 1 MW central solar thermal power station, probably in Italy; and Spain is in the process of locating a site for a solar research institute with help from the United States and several European countries.

Up-to-date data on other nations' solar programs or budgets have not been compiled by ERDA; the most recent is a February 1976 report by the Atlas Corporation. Although Atlas has proposed that ERDA update the study, the project has not yet been funded.[2]

The U.S. policy of sharing its solar technology with other countries, for the mutual benefit of all involved, is well established. In 1975, the Agency for International Development (AID) produced a preliminary study of the energy requirements of the developing countries. Last year ERDA and AID signed an agreement to begin helping those countries to meet their energy needs. For example, under the agreement ERDA is now contracting a project to install, at a cost of about $75,000, a solar photovoltaic pump to provide drinking water in a village in Upper Volta.

The United States, with ERDA as the prime agency, is also involved in a number of multilateral and bilateral solar research projects with other industrialized nations; other agreements are expected to be reached in the near future.[3] Solar activities with other countries are also being developed under the auspices of programs administered by the Department of State and the National Science Foundation.[4]

1.5 *U.S. leadership*

The United States is in a position to lead the global development of solar energy resources. That leadership can take three forms, the first being technological. As the most technologically advanced nation in the world, U.S. efforts in solar energy are being closely watched by other nations concerned about their energy future. Results of American research and development, including demonstrations of more advanced solar techniques, may well determine the direction taken by other countries in coming years.

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[2] For summaries of the solar programs of a number of other nations, see Appendix I.
[3] Summary of International Activities, ERDA.
[4] For a more detailed outline of U.S. solar agreements, see Appendix II.

The second area for U.S. leadership involves financial and technical assistance. Relevant measures might include the establishment within the World Bank of a fund for loans to developing countries for investment in solar energy facilities. Export-Import Bank policies could be adapted to encourage U.S. corporations in the solar energy field to invest abroad. Finally, direct grants and loans by AID can be used to facilitate solar energy applications in the developing countries.

The third dimension of a U.S. leadership role would involve a more subtle factor: emulation. The prestige of U.S. technology is such that a substantial U.S. investment in solar energy might stimulate other nations to follow suit. A distinct national commitment by the United States to solar energy as a practical working way to provide a sizeable fraction of its energy needs in the coming decades, could have a definite (but undeterminable) effect upon other nations. That U.S. commitment could, for instance, take the form of a decision to install solar heating and cooling equipment on U.S. embassies or State Department housing, and military bases abroad, where practical. Such a project would have a number of benefits. It would stimulate the American solar construction industry. It would give the United States valuable information on how solar works in a variety of climates and conditions. And, perhaps most importantly, it would demonstrate to virtually every nation in the world that the United States is indeed serious about solar energy.

VIII.2 THE IMPACT OF SOLAR ENERGY ON AMERICAN LABOR

Onsite solar technology appears to be more labor-intensive than contemporary techniques for supplying energy, thus, in the short term, the introduction of solar energy devices might create jobs in trades now suffering from serious unemployment. In general, the new jobs will be distributed widely across the country and will not require laborers to live in remote or temporary construction sites because most workers should be able to find jobs in areas close to their homes. Work on solar equipment, for the most part, should necessitate only simple retraining programs although there may be shortages both of engineers and architects qualified to design solar equipment, and of operators trained in maintenance of some of the larger and more sophisticated solar devices which have been proposed.

Assessing the long-term implication of technological development on the work force, however, cannot be reliably undertaken with contemporary economic methods. Long-term labor impacts will depend on forecasts of future growth rates both in the economy and in U.S. energy consumption—subjects about which there is great confusion and disagreement. Although making economic projections is hampered by imprecise methodology, it is possible at this point to outline some of the critical issues which concern the effects of solar energy development on labor.

2.1 *Manpower requirements*

One of the most critical issues in evaluating the impact of a new energy technology on labor, and one of the most difficult to deal with reliably, is how the technology will affect overall manpower requirements in the energy industry. Tables VIII–2 and VIII–3 compare the manpower requirements of a conventional coal-fired generating system with the manpower required to construct and to operate each of two kinds of solar devices capable of producing equivalent amounts of energy. Only first order effects have been considered, and the estimates made about solar devices are necessarily speculative. One overall conclusion seems inescapable, however: a large fraction of the value of solar equipment is attributable to direct labor costs.

The high labor intensity of solar equipment is not surprising. Most devices can be constructed from relatively inexpensive material, and the small equipment examined here would not require extensive capital-carrying charges during construction. Although factories for mass-production of photovoltaic devices, heat engines, and other components of solar technologies will probably employ sophisticated and expensive equipment which will reduce labor in these industries in the future, a large fraction of the work involved with installation of solar equipment requires direct onsite labor, will probably not be substantially reduced.

Table VII–2 lists all labor requirements for construction at the plant site, to build the 800 MWe turbine generator in a factory, to operate the generating facility at an average of 75 percent full capacity for a period of 30 years, to build a coal mine large enough to support the plant, to operate the mine, to transport the 2.5 million tons of coal per year needed to operate the plants, and to construct and maintain a transmission and distribution network. It is noteworthy that the labor for annual operations is more than 40 percent greater than the labor needed to construct the facilities, and that nearly 40 percent of the manpower requirements in operations are used to maintain the distribution facility.

Table VII–3 shows the labor requirements for a flat-plate solar water heater and for a small tracking photovoltaic device. It is apparent that if all conventional power were replaced with solar units, labor requirements would be multiplied by a factor of 2 to 5. The multiplier would be even higher if a substantial amount of conventional generating equipment was required to provide backup to the solar system. (The most economic use of solar energy requires some conventional power system backup.)

The major source of error in these estimates, apart from inaccuracies in data gathering, is the failure to consider the many secondary kinds of employment which could be created by both solar and conventional facilities. A significant fraction of this secondary labor would come in the manufacture of primary metals, glass, etc., for both solar and conventional systems. Given that the weight of solar devices would be equal to or more than conventional systems per unit output, it seems unlikely that the differences in labor requirements illustrated above would be eliminated by a more detailed analysis.

TABLE VII-2.—LABOR REQUIREMENTS FOR A CONVENTIONAL 800-MWe COAL PLANT

[In units of man-hours per megawatt-year]

	Construction	Operating and maintenance	Total
800-MWe coal plant	270	320	590
Coal strip mine using western coal	20	370	390
Coal transportation	20	150	170
Electric transmission	50	1	51
Electric distribution	140	540	680
Turbine/generator manufacturing	170	0	170
Total	670	1,380	2,050

Assumptions: 800-MWe coal plant operating at 75 percent peak capacity for 30 yr; western coal strip mine with 40-mi train line and 237 train round trips per year; all data based on Bechtel data with the exception of the turbine generator manufacture. It was assumed that the turbine/generator cost of $150/kW of which 25 percent was labor and that this labor was paid at an average rate of $10/hr; calculations divide the sum of construction manpower and 30-yr operating manpower requirements by the total number of megawatt-years of energy produced by the plant.

Source: "Resource Requirements, Impacts, and Potential Constraints Associated With Various Energy Futures," the draft annual report of Bechtel Corp. to ERDA, November 1976 (No. APAE-11735-76-1).

TABLE VII-3.—LABOR REQUIREMENTS OF 2 TYPES OF DISTRIBUTED SOLAR ENERGY SYSTEMS

[In man-hours per megawatt year]

	Construction	Operations and maintenance	Total
I. Solar hot-water heaters (8m² flat plate):			
Manufacture collector	900-1,800	0	900-1,800
Install collector	2,500	0	2,500
Routine O. & M		700-1,400	700-1,400
Total for hot-water system [1]	3,400-4,300	700-1,400	4,100-5,700
Total for hot-water system, including backup	3,740-4,640	------------	4,440-6,040
II. Tracking silicon photovoltaic system (50 m²):			
Manufacture collector and cells	3,000	------------	3,000
Install collector	1,700-5,500	------------	1,700-5,500
Operate system		1,200	1,200
Total for tracking photovoltaic system	4,700-8,500	1,200	5,900-9,700
Total for tracking photovoltaic system, including backup	5,040-8,840	------------	6,240-10,040

[1] Since electric water heaters are typically only 70-percent efficient, the man-hours per megawatt-year of solar thermal energy applied to hot water cannot be compared with the man-hours per megawatt-year of electricity illustrated in the previous table. The man-hours required to produce a megawatt-year of electric hot water would be 42 percent larger than the man-hours displayed in the previous table.

Assumptions: 20-yr system life; installation includes 75 ft of piping costing 0.12 MG/ft to install; flat plates installed for 1.3 MH/m^2 and tracking collector installed for 0.83 to 3.33 MH/m^2; cells assumed to be 18-percent efficient, optical efficiency 80 percent; labor for providing backup power is assumed to be 50 percent of the construction labor shown in table VII-4 (e.g., 340 man-hours/MW-year)

Source: Prepared by OTA using manufacturer's data.

2.2 Some qualitative impacts

While the analysis of the overall labor requirements of solar energy is very primitive, it is possible to be somewhat more confident about some qualitative aspects of solar energy's impact on the work force.

(*a*) *Geographic distribution.*—Employment in installation and operation of solar equipment can be expected to be distributed over a large part of the country. Initial installations of solar equipment are likely to occur in places with high insolation—the South and Southwest. Locations with relatively low levels of sunlight, such as the Northeast, however, tend to have high energy prices. Thus, while low insolation levels make solar energy in the North expensive, competing energy sources are also expensive so the net economic competiveness of solar devices may be as high in the North as in more favorable climates. Employment in installing solar energy is, therefore, likely to be as geographically dispersed as the building industry. One thing about solar employment seems clear—none of the small solar devices considered in this report will require the major dislocation of a work force, or the establishment of temporary work camps as may be required for construction of a pipeline, an offshore drilling operation, or a large central generating facility in a remote location. The relatively small solar devices analyzed here will provide employment in close proximity to where workers presently live, and therefore will avoid the social disruptions associated with large influxes of temporary workers.

Unlike most major manufacturing facilities, solar manufacturing at present is spread across the country in literally hundreds of small companies. The future of these businesses, however, is very uncertain. If the demand for solar equipment increases substantially, the field may be dominated by a small number of large manufacturing firms, much as the manufacturing of conventional heating and cooling equipment is dominated by a small number of firms. On the other hand, solar devices may be designed for special climates and sufficiently site-specific for manufacturing to remain geographically dispersed, much as facilities for manufacturing modular homes are today. It seems clear that because of the sophisticated technology employed, the manufacturing of components such as photovoltaic devices, and heat engines, and concentrating devices will occur in a relatively small number of facilities.

(*b*) *The stability of labor demand associated with solar equipment.*—If a major demand develops for solar energy, it is likely that employment in the area will be as stable as work in any typical building trade; the solar equipment will simply add jobs at each construction site. If a major retrofit market develops, there could also be major employment opportunities in this area; maintenance of solar equipment will also provide a stable source of jobs.

(*c*) *The skill levels required.*—Most of the employment directly created by a shift to solar energy will be in installation of the equipment by the conventional building trades, and in the creation of new manufacturing industries. The skills required for installation of the equipment will be very similar to those required for conventional construction projects, although some brief training programs will undoubtedly be desirable to familiarize workers with the new equipment and its installation. Most of the work will be in framing roofs, laying footings, plumbing collectors and storage tanks, excavating trenches and pits for pipe-runs and storage tanks, installing sheet metal ducting, insulating pipes and tanks, installing electronic control units, etc. The work will be nearly identical to the installation of sophisticated air-conditioning and heating systems in conventional buildings.

Larger solar installations, such as those serving groups of buildings and large industrial operations, are likely to require supervisors, managers, draftsmen, designers, and engineers in roughly the same proportion as these skills are required in the construction of conventional power-generating facilities. In fact, since many large onsite solar facilities are likely to be supplemental to conventional boilers and generators, the solar equipment would simply add work in these areas at each installation. There may be a shortage of engineers with adequate knowledge in areas critical to onsite power in general and solar devices in particular. Designing a reliable and efficient onsite device for a large installation (such as an apartment or industry) requires experience with other types of equipment not now conventionally used in utility or building energy systems and solar onsite requires even more expertise in order to manage the added complexities of collector design, thermal storage systems, and more elaborate control systems, and possibly of batteries, heat-engines, and photovoltaic devices.

Employment opportunities in manufacturing are more difficult to define, since the pattern of growth in the industry is presently unpredictable. Work opportunities will include glazing, metal extrusion, component assembly, and chemical processing (for photoelectric devices, selective surface formation, storage systems, etc.). It is difficult to anticipate whether the employment will be created in a large number of dispersed fabricating facilities, in large central plants, or in both.

The skills required to maintain the type of simple solar equipment installed on homes and small apartments will be similar to those required for conventional appliance maintenance of utility gas and electric power equipment. Most of the personnel engaged in these professions will clearly require some additional specialized training in solar technology. There is, however, a very serious shortage of persons with the skills needed to operate intermediate-sized solar or conventional onsite energy equipment: owners of small total energy systems have frequently complained about the difficulty of finding and holding persons with appropriate training in operation and maintenance of engines and heat recovery units, energy control switching, and other associated equipment. Maintenance of a sophisticated collector system will present similar problems. Many of the persons now employed in the operation of total energy systems have been trained in the requisite skills by the U.S. military services; such training is apparently difficult to obtain in private industry.

Tables VII–4 and VII–5 demonstrate jobs which must now be done to support conventional electric generating equipment. The impact of solar equipment on jobs will depend on the extent to which solar devices displace fuel consumption (replacing jobs in mining with jobs in solar technologies), the extent to which the technology would cut the demand for peak generating capacity (replacing jobs in constructing and maintaining generating equipment with jobs in solar technologies), and the extent to which the need for transmission and distribution equipment would be reduced. These effects are listed in the order of their likelihood: It is most probable that solar technology would initially affect only fuel utilization, and would affect transmission and distribution requirements only in an extreme case where all or a very large fraction of local energy needs are met with solar equipment. It should not be assumed that an increase in solar utilization would necessarily replace any of the employment indicated in tables VII–4 and VII–5. The expected increase in U.S. and worldwide demand for coal, for example, is likely to be so large that employment in mining would not be affected by an expected penetration of solar energy into the market. Several observations can be made on the basis of the tables, however:

Small solar installations are likely to employ more blue collar workers than professional employees. Solar installations on individual buildings typically require one supervisor for each ten workmen,[5] while the ratio for the conventional coal equipment shown in table VII–4 is closer to 1 to 3. The larger industrial and community solar systems would, however, require much more professional work.

Nearly 50 percent of the jobs associated with operating and maintaining conventional equipment is associated with coal mining and transportation. Jobs in these sectors could be replaced with jobs in repair and maintenance of onsite equipment.

About 40 percent of the work required to build a conventional electric system and 30 percent of the work required to maintain it is associated with distribution equipment, which is unlikely to be affected by solar technology.

TABLE VII–4.—SKILLS REQUIRED FOR CONSTRUCTING A COAL-FIRED ELECTRIC GENERATING PLANT AND OPERATING THE SYSTEM OVER A 30-YR PERIOD[1]

I. SKILLS REQUIRED FOR PLANT CONSTRUCTION (AS A PERCENTAGE OF THE 3,774 MAN-YEARS REQUIRED TO CONSTRUCT THE PLANT AND THE TRANSMISSION AND DISTRIBUTION NETWORK)

	Coal-fired electric generating plant	Transmission and distribution facilities	Total (percent)
Nonmanual construction work	10 percent (63 percent engineers and 25 percent supervisors).	12 percent (50 percent electrical engineers, 25 percent draftsmen and designers).	22
Manual construction work	48 percent (variety of trades).	28 percent (40 percent electrical engineers, 30 percent draftsmen and designers).	76
Total, construction work	58 percent	42 percent	100

II. SKILLS REQUIRED TO OPERATE AND MAINTAIN EQUIPMENT FOR A 30-YR INTERVAL (AS A PERCENTAGE OF THE 9,692 MAN-YEARS REQUIRED)

	Coal mining and coal transport	Coal-fired generating plant	Transmission and distribution facilities	Total (percent)
Nonmanual operating work	15 percent (mostly trainmen).	8 percent (66 percent supervisors and managers).	4 percent (mostly supervisors working on distribution system).	27
Manual operating work	32 percent (mostly miners).	19 percent (variety of trades).	23 percent (mostly electricians and meter readers for distribution system)	73
Total, operating employment	47 percent	27 percent	27 percent	100

[1] Details about assumptions used shown in table VIII–5.

Source: Based on data in "Manpower, Materials, and Capital Costs for Energy-Related Facilities," Bechtel Corp., April 1976.

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[5] FEA Project Independence Task Force Labor Report.

TABLE VII-5.—DETAILED BREAKDOWN OF SKILLS REQUIRED FOR CONVENTIONAL ELECTRIC SYSTEM

	Western strip mine (annual operations)	Coal Transport unit train (annual operations)	Coal-fired elastic generating plant (800 MW)		Electric transmission (200 mi in length and national average		Electric distribution				Total construction and 30 yr operation
			Annual operations	Construction	Annual operations	Construction	Annual operations	Construction	30 yr of operations	Construction	
Nonmanual Manpower											
1. Engineers:											
Conductor	0	37	0	0	0	0	0	0	1,110	0	
Civil	0		1	108	.02	12	1	86	161	206	267
Electrical	.06		4	79	.08	25	3	171	214	275	489
Mechanical	.06		2	62	.02	5		29	62	196	158
Mining	.55		0						17		17
Industrial	.06		0						2		2
Safety	.09		0						3		3
Environmental	.04		0						1		1
Total engineers	.86	37	7	249	.12	42	4	286	1,469	577	2,046
2. Designers and draftsmen	.85	0	1	100		17	0	116	56	233	289
3. Supervisors and managers	6.70	0	17	47	.23	3	9	19	988	69	1,057
4. Total nonmanual manpower	12.0	37	25	396	.35	61	13	421	2,620	879	3,499
Manual Power											
1. Pipefitters	7		108	477					450	477	927
2. Pipefitter/welder			12	214			3		450	214	669
3. Electrician			12	334	0.4	133	38	897	1,512	1,364	2,876
4. Boilermaker			8	358					240	358	598
5. Boilermaker/welder			0	119					0	119	119
6. Iron worker			0	167		44			0	211	211
7. Carpenter			0	167						167	167
8. Equipment operators	40		20	119					2,400	119	2,519
9. Other	8		0	142	.2		31		6	142	148
10. Total technical manpower	66	37	60	1,521	.72	177	72	897	7,072	2,895	9,967

(*d*) *Working conditions.*—Expansion of the solar energy industry should not raise serious health or occupational hazards, but some of the possible problems are discussed below. The manufacture of some photovoltaic devices employs cadmium and arsenic compounds which could present hazards to workers assembling these units. This situation would not be unique, however, because these compounds are widely used in other industries. Some steam-fitting jobs will involve high-pressure steam lines, and some proposed thermal storage methods will require very hot oils, possibly explosive or toxic. These issues deserve serious attention before such installations become commonplace. Devices using hazardous material may only be employed in larger, more centralized solar facilities and are unlikely to be found in onsite residential systems. Replacing jobs in coal mining for those in solar equipment maintenance, however, would probably result in overall improved working conditions.

(*e*) *Organized labor.*—Organized labor is enthusiastic about solar energy's potential for creating jobs. Like many other construction trade unions, the sheet metal workers (SMWIA) have been hard hit by unemployment: the SMWIA has a national unemployment rate of 30 percent to 35 percent, with unemployment reaching 50 percent to 60 percent in some areas of the West and Southwest.[6] Coincidentally, these are precisely the areas where solar heating and cooling is most cost effective, and will no doubt be among the first areas with widespread utilization of solar technologies.

In 1970, the plumbers and pipefitters have a nationwide unemployment rate similar to that of the sheet metal workers. A potential labor problem associated with implementation of solar technology is the question of which union will subsume the categories of newly created jobs. Until recently there have not been many solar installations so that few unions have staked out territorial prerogatives. For the most part, the solar energy field is still wide open to jurisdictional competition. The situation can be expected to change as more work in the area becomes available. An arrangement has already been negotiated between the Sheet Metal Workers and the United Association of Plumbers and Pipefitters which calls for joint crews in the installation of hot air collectors using liquid storage systems. Jurisdictional disputes could be a serious problem in other areas, however, unless all issues can be settled as amicably as this one has apparently been.

Generally, union officials feel that an upsurge of solar construction and installation would not radically alter the types of jobs available to union members, but rather the number of jobs. Firms that now produce heating, ventilating, and air conditioning equipment—many of them already into solar collector construction—would simply expand their operations. Any new firms established would be unionized in conventional ways.

While labor has occasionally resisted the introduction of new technologies into the building industry, this resistance has always been directed at technologies which reduce jobs on each building site or which transferred employment from one building trade to another. The disputes associated with the introduction of plastic plumbing, prehung doors, and metal studs, all resulted from one of these effects. Solar equipment would add work at each site without displacing work in other areas, and it is, therefore, difficult to imagine any group with a motive to resist its entry into the market.

2.3 *Long-term impacts*

The overall impact of generating a substantial fraction of U.S. energy from small solar devices is extremely difficult to assess since current economic theory has failed to develop satisfactory methods for conducting such analysis. None of the major price equilibrium models used to determine the future of U.S. energy supply and demand adequately treat employment issues; most make the overwhelmingly simple assumption that there will be full employment during the entire period analyzed. As a result, many of these models tend to ignore the influence of alternative energy strategies on unemployment. The difficulties of predicting economic impacts are magnified by the fact that much of the information necessary to translate a workable theory or model into useful policy information does not presently exist.

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[6] James K. Crump, Chief International Representative, SMWIA.

In the absence of an adequate methodology, the most critical questions involving the impact of solar technologies on the work force cannot be answered with certainty. An example of one difficulty can be seen in the problems associated with interpreting the implications of labor intensity. If rapid rates of growth are expected in both the U.S. economy in general and the energy production sector in particular, and if unemployment is expected to be very low as a result, any shift to a labor-intensive technology like solar energy could prevent wages from keeping pace with growth in other sections of the economy. An industry with high labor intensity requires more manpower for the same output than industries with low labor intensity. As a result, the average wage paid per worker must be lower for the labor-intensive process. If growth is not expected to be sufficient to eliminate unemployment, labor-intensive industries will be beneficial to both labor, and to society as a whole, by permitting a larger fraction of the work force to be productively employed.

Other questions which must be addressed include the following:

(1) Would the energy produced by solar equipment fill a shortfall in energy supplies resulting from a failure of alternative sources to meet energy demands, thereby allowing an expansion of labor in solar industries without reducing employment in other areas? (If solar energy filled an unsatisfied need, it would permit expansion of employment in those areas of the economy not otherwise possible.)

(2) To what extent will solar energy sources be able to reduce the need for installing additional electric generating facilities and to replace expendable fuels? If fuels are replaced, what types of fuel would these be? (If solar energy replaces only fuel and does not reduce the demand for generating equipment, solar energy would probably only replace imports and would not directly affect employment in the energy sector. If, on the other hand, it reduced the demand for new electric generating facilities, it could have some impact on the demand for construction labor in this sector. As mentioned above, if solar facilities fill a demand which would not be possible or desirable to fill by expanding conventional capacity, it would not displace jobs anywhere in the economy.)

(3) Would the energy production by solar equipment reduce imports of oil and gas, or would it displace domestic energy supplies of coal or nuclear fuel? If imports are reduced, and funds invested instead in areas benefiting labor in the solar industries, would employment be reduced in industries now benefiting from the export market stimulated by our purchase of foreign fuels?

(4) What kinds of growth rates can be expected in energy sources which do not depend on solar energy? Will this growth rate be constrained by a shortage of capital, resources, and demand, or by a shortage of critical skills? Would solar energy compete directly for scarce resources or would it be able to tap other capital or labor supplies?

(5) What kind of work force dislocations could be expected in a shift from one energy source to another? Would new skills not now available in the building trades be demanded? What kinds of transient unemployment could be expected in this transition?

RESOURCE REQUIREMENTS AND DISPLACEMENT OF ALTERNATIVE ENERGY SOURCES

SOLAR PROGRAM ASSESSMENT: ENVIRONMENTAL FACTORS—SOLAR TOTAL ENERGY SYSTEMS

(From the Division of Solar Energy, Environmental and Resource Assessments Branch, Energy Research and Development Administration, March 1977)

A. Introduction

The purpose of this section is to provide a basic idea of STES resource requirements and energy displacement. STES sizing and component usage will vary greatly depending upon specific applications. The employment of different technologies, especially in the electricity production function, will cause wide variations in resource requirements as well as in the ability of the system to displace alternative sources of energy.

B. Resource requirements

The electric generating plant and storage portions of an STES will require relatively large amounts of common materials such as concrete, steel, glass, and aluminum. These requirements for both central receiver and distributed collector systems are presented on a tons/MWe capacity basis in Table III–1. The resources required for the thermal distribution subsystem will consist mostly of metal piping, the amounts of which will vary widely in relation to STES design, layout, size, and the number of individual units to be heated or cooled. Most of those materials are readily available with the possible exception of aluminum, the production of which may be constrained, by reliance on imported bauxite ore. Chrome supplies also stem largely from imports. Materials availability, however, is not expected to be a limiting factor in STES development.

TABLE III–1.—CRITICAL MATERIALS REQUIREMENTS FOR SOLAR TOTAL ENERGY SYSTEMS (ELECTRICITY GENERATION AND THERMAL STORAGE)

[In megawatts electrical]

Critical materials	Central receiver		Distributed collector	
	Tons	Metric tons	Tons	Metric tons
Steel	500–700	(450–630)	700–1, 000	(630–910)
Concrete	1, 500–2, 500	(1, 360–2, 270)	500–1, 000	(450–910)
Glass	50–100	(45–90)	4–6	(3. 6–5. 4)
Aluminum	20–50	(18–45)	24–30	(22–27)
Copper	5–10	(4. 5–9)	5–10	(4. 5–9)
Plastic	5–20	(4. 5–18)	40–60	(36–54)
Insulation	20–40	(18–36)	25–30	(23–27)
Chrome/titanium	1–2	(0. 9–1. 8)	4–6	(3. 6–5. 4)
Silver	0. 01-0. 05	(0. 01–0. 05)	0. 005–0. 01	(0. 005–0. 01)
Miscellaneous	5–10	(4. 5–9)	5–10	(4. 5–9)

Source: Mitre Corp., "Analysis & Planning Support for ERDA DSE."

C. Displacement of alternative energy sources

By using solar energy to generate electricity and provide building heating and cooling, solar total energy systems can significantly reduce the consumption of the fossil fuels presently used in these applications. Sandia Laboratories has estimated on a comparative basis the fuel and other operating costs associated with running a 1,000-identical dwelling community. A non-solar total energy system powered solely by fossil fuel-fired boilers would result in 56 percent of the operating costs over the life of the system going toward fossil fuel purchases. Fossil fuels consumed in this instance would still be well below the amounts required if electricity and heating and cooling were provided separately and, in the case of the latter, on an individual basis (that is, if a total energy configuration were not employed). The imposition of a solar thermal electric system to power the turbo-generater, fossil fuel being used only for auxiliary purposes, would further reduce total fossil fuel consumption. It is estimated that solar energy on the average could provide 64 percent of the STES energy requirements, the remaining 36 percent being provided by fossil fuels. Over the life of the system, then, fossil fuel costs could be cut from 56 percent of the overall operating budget in a non-solar total energy system to 19 percent in a solar total energy system.

TABLE II–1.—*Resource requirements baseline solar heating and cooling system*

Flat plate collector:[1]	
Steel	69. 64 lb (31. 65 kg).
Glass	31. 80 lb (14. 45 kg).
Aluminum	10. 13 lb (4. 60 kg).
Copper tubing	6. 80 lb (3. 09 kg).
Insulation (fiberglass)	5. 25 lb (2. 39 kg).
Miscellaneous	3 lb (1. 36 kg).
Thermal storage tank:[2]	
Steel	1, 235 lb (561 kg).
Insulation (foam)	∼26 lb (∼12 kg).
Heat exchangers: Copper tubing	∼50 lb (∼23 kg).
Absorption air conditioner:[3]	
LiBr solution	80 to 90 lb (36–41 kg).
Steel	700 to 750 lb (318–341 kg).
Copper	∼30 lb (∼14 kg).
Stainless steel	∼18 lb (∼8 kg).
Wet cooling tower:[4]	
Steel	323 to 362 lb (147 to 165 kg).
Stainless steel	3 to 4 lb (∼1 6 kg).
Zinc	14 to 16 lb (6.4 to 7.3 kg).
Asbestos	60 to 68 lb (27 to 31 kg).

[1] Based on one 6 by 3 ft. by 6 in. (1.8 m. by 0.9 m. by 15 cm) modular panel manufactured by the Honeywell Corp. collector square footage should be from ⅛ to ½ the building square footage.

[2] 1,000 gallon (3,790 1) capacity manufactured by the Buffalo Tank Co.

[3] 3-ton (2.7 metric tons) unit manufactured by Arkla Industries.

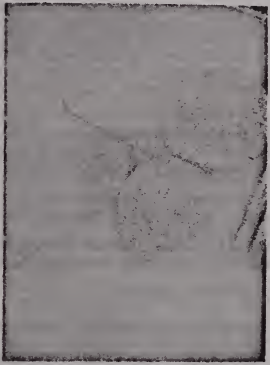
[4] Appropriate sized unit manufactured by Marley Cooling Towers.

* * * * * * *

F. *Material resource requirements*

Solar system designs will vary greatly, and thus it is difficult to assess the types and quantities of materials necessary for their construction. Materials requirements presented in Table II-1 are approximate figures for a typical baseline solar heating and cooling system. These figures will vary with design and application. (Conventional auxiliary systems and ductwork are not included.) Most materials used in solar heating and cooling systems, with the possible exception of copper and chrome, are widely available in sufficient quantity. Solar system deployment is not expected to significantly impact the availability of these materials, although aluminum production may be constrained by heavy reliance on imported bauxite ore.

Preliminary Analysis of an Option for the Federal Photovoltaic Utilization Program (FPUP)



This technical report was funded by the FEA under Purchase Order PO-05-77-4965-0. (This work is a revision and expansion of a Draft preliminary cost benefit analysis of FPUP dated March 11, 1977, funded by the FEA under the Interagency Agreement between the DOD and FEA No. CG-05-50081-1, "DOD Photovoltaic Energy Conversion Systems Market Inventory and Analysis.")

The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies of the U.S. Government.

Federal Energy
Administration

Task Force on Solar
Energy Commercialization

July 20, 1977

FEDERAL ENERGY ADMINISTRATION ACTIVITIES

The Federal Energy Administration (FEA) is involved with the development and use of solar energy encompassing a broad range of interests including: the direction of the Nation's solar-related endeavors as part of our National energy strategy; the policy, planning and overall coordination of solar energy commercialization; and certain regulatory and resource management functions which affect the use of solar energy.

FEA's legislative authority for solar-related activities is based on a number of laws including P.L. 93-275, P.L. 93-438, and P.L. 94-385. Of significance, the Energy Conservation and Production Act (P.L. 94-385) authorizes FEA to "provide overall coordination of Federal solar energy commercialization activities" and "to carry out a program to develop the policies, plans, implementation strategies, and program definitions for promoting the accelerated utilization and widespread commercialization of solar energy." As part of P.L. 94-385, the Congress listed several solar energy commercialization activities which it expects FEA to carry out, a few of which include:

- "Develop a national plan for the accelerated commercialization of solar energy to include workable options for achieving on the order of one million barrels per day of oil equivalency in energy savings by 1985 from a combined total of all solar technologies;"
- "Develop commercialization plans for each major solar technology;"
- "Conduct studies and analyses addressing mitigation of economic, legal, environmental, and institutional constraints;"
- "Develop such major commercialization projects as, but not limited to, the 'Southwest Project,' the 'Solar Energy Government Buildings Project,' among others."
- "Develop State solar energy commercialization programs."

In addition to the preliminary Federal Photovoltaic Utilization Program Initiative analysis, FEA is involved with or initiating a number of efforts which could affect the commercialization of photovoltaics. These include: support of the President's proposed National Energy Plan which recommends residential and business tax credits, utility regulations for peak load and declining block rate pricing reforms, and regulations and taxes discouraging use of oil and gas; analysis of near term markets for photovoltaic systems within DoD; Southwest Project; Export Market Initiative; loan guarantees for renewable resource energy measures; and certain new photovoltaic initiatives.

FOREWORD

During the first 90 days of President Carter's Administration, a large number of energy initiatives were being prepared and reviewed for possible inclusion within the National Energy Plan (NEP). Among these was the "Federal Photovoltaic Utilization Program" (FPUP) initiative. The White House Energy Policy and Planning Office requested the Federal Energy Administration (FEA) to prepare an initiative based on Title II of S 672 (95th Congress) which called for the establishment of a Federal Photovoltaic Utilization Program. A modified program option was developed for the FPUP initiative--somewhat similiar to the program specified in HR 7629 (95th Congress)--and its feasibility was assessed.

At that time, a related study entitled "DoD Photovoltaic Energy Conversion Systems Market Inventory and Analysis" was being completed for FEA through an interagency agreement with the Department of Defense (DoD). The interagency agreement with DoD provided for a number of tasks including analysis of an "accelerated scenario" of rapid DoD procurement of photovoltaic systems. Also, the interagency agreement called for technical support for commercialization analyses. Through these provisions, the DoD and their prime contractor for photovoltaic energy conversion, The BDM Corporation of McLean, Virginia, developed the cost/benefit analysis for the initiative. The product of these efforts was a draft preliminary cost benefit analysis dated March 11, 1977.

A number of comments from within FEA, the White House Energy Policy and Planning Office, DoD, the Energy Research and Development Administration, other agencies, and private industry were made on the March 11, 1977 draft. A limited analysis was undertaken by The BDM Corporation (under a purchase order with FEA), to address these comments and expand the original analysis. This report documents the additional analysis. Though the direct level of effort by the contractor on the additional analysis was not large, i.e, approximately 2 man-months, the value of the effort was greatly enhanced by a number of factors including: extensive review by industry and government of the analysis; substantial ongoing, related contracts with ERDA and DoD; and the March 11th analysis.

The Federal Photovoltaic Utilization Program option, according to this analysis, could provide a significant, cost effective incentive for the accelerated development of an innovative highly competitive industry capable of producing low cost, quality, photovoltaic systems.

The next step, which is now being initiated, is expected to be the development of a "detailed policy/implementation plan for the Federal Photovoltaic Utilization Program" which would address a number of implementation options along with the costs and benefits for each. The policy/implementation plan would be necessary to facilitate the rapid and orderly implementation of a better designed commercialization project, if and when the Program is approved. Also, the policy/implementation plan is to be prepared in conjunction with a comprehensive photovoltaic commercialization analysis which would examine a number of possible combinations of government actions and policies for accelerating the commercialization of photovoltaics energy systems. These combinations, or commercialization strategies/options could include such actions and policies as certain FPUP options, other guaranteed markets, tax credits, loan guarantees, utility regulations for peak load and declining block rate pricing reforms, regulations and taxes discouraging use of oil and gas, and new photovoltaic initiatives.

ACKNOWLEDGMENTS

This report was prepared under the guidance of Mr. Samuel J. Taylor of the Federal Energy Administration (FEA) Task Force on Solar Energy Commercialization. It was prepared by The BDM Corporation under FEA Purchase Order No. PO 05-77-4965-0. The BDM Program Manager was Dr. Orin H. Merrill. He was assisted by Mr. J. C. Belote, Dr. Mary R. Hamilton, Mr. J. Scott Hauger, Ms. Judy Isreal, and Dr. Richard A. Moyle of the BDM Professional Staff. Numerous copies of the draft final report (dated May 13, 1977) were circulated for review within FEA, ERDA, DOD, other areas within the Executive Branch, and to industrial participants in the photovoltaics industry. All comments received were carefully considered in preparing this final report. The FEA wishes to acknowledge those organizations and persons that reviewed and commented upon the draft document. The list of the contributors is too extensive to acknowledge each individually.

LIST OF SYMBOLS AND VALUES

P/V = Photovoltaic
LANGLEY=L = Measure of Solar Radiation (Insolation) = 1 GM-CAL/CM^2
= 4.2 WATTS-Sec-CM^{-2}
Si = Silicon
GaAs = Gallium Arsenide
W = Watt = 3.413 BTU/HR = $1.341.10^{-3}$ Horsepower
Wp, We = Peak Watt (for Photovoltaics) and Watt Electric, respectively
WHR = Watt Hour = 10^{-3} Watts KWHR = 3.413 BTU
KW = Kilowatt = 10^3 Watts
MW = Megawatt = 10^3 KW = 10^6 W
KWHR = Kilowatt Hour = 3413 BTU = 1.341 Horsepower-Hour
MWHR = Megawatt Hour = 10^3 KWHR
M = Meter = 3.281 Feet
M^2 = Square Meter = 10.76 Ft^2
Amp = Ampere
AC = Alternating Current
DC = Direct Current

DEFINITION OF COMMERCIALIZATION

Commercialization by the private (non-government) sector may be defined as a process whereby a new type of product, system, technique, manufacturing process or service moves from a merely technology availability status to a status of marketplace acceptance, consumption, and profitability. The commercialization process is considered to be successful when the venture has proven to be economically viable and private capital represents the primary source of financing.

The process for the successful commercialization of a new system is long and complex. It begins at the conceptual stage with an idea of identified need for a new system, product, or service, or, through financial pressures or opportunities, the development of a new approach to a particular problem. From here it may proceed as follows:

- The "need or idea" must be further defined, the potential market assessed and engineering development, production, and marketing costs projected.
- If initial product costs and marketability appear viable, preliminary funding must be secured for initial efforts, and sources of extended financial support solicited.
- The regulatory environment must be examined and patent privileges defined.
- Market strategy and engineering/product development efforts are undertaken.
- The practicality of the new system must be demonstrated and its possible environmental impacts determined.
- Management actions are undertaken, e.g. site acquisition, tooling and industrial engineering, labor force training, etc.
- New venture groups, organizations, or operations may need to be formed to conduct a specific commercialization effort.

DEFINITION OF ACCELERATED COMMERCIALIZATION

Accelerated Commercialization-- a joint government-private sector process-- might be defined as government actions that are taken to increase the rate, level, and breadth of both acceptance and utilization of a new type of product, system, technique, manufacturing process or service. The general objective of such government actions should be to achieve the maximum market penetration rate of the new type of system, at a given level of government expense, while minimizing any possible negative socio-political impacts of the system. Such government actions, in general, can take the form of:

- Stimulating market demand;
- Stimulating the early development of a viable, self-sustaining (i.e., not requiring government subsidies) industry/market infrastructure; and
- Mitigating, where possible, any technical, economic, legal, institutional or environmental constraints.

It should be strongly emphasized that government actions in the form of accelerated commercialization policy and planning efforts must proceed concurrently, and not just sequentially, with government and private sector research, development, test and evaluation (R, D, T&E)* efforts. Concurrent action is necessary because, in many instances, market development requires a longer lead-time than does an R, D, T&E effort. For example, preparing the manufacturing industry, the market place, and the associated institutions for large-scale integration of wind energy generators or photovoltaic power systems into Federal hydro-electrical systems, let alone private utility systems, may take up to five years. However, the technology may be available in two to three years. In such cases effective Federal accelerated commercialization planning (i.e. in line with market development lead-times) should be initiated early enough to permit rapid implementation as soon as technical feasibility has been demonstrated.

Furthermore, certain *dispersed* solar technologies such as solar heating and cooling and photovoltaics, are each concurrently in different phases (e.g., planning, implementation, etc.) of commercialization readiness. Solar water heating and certain military, remote site, and foreign photovoltaic applications are ready for accelerated commercialization implementation today. Residential cooling (by photovoltaic powered or absorption air conditioning) is ready for accelerated commercialization planning today and actual implementation in the early 1980's.

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*It should be noted that the *demonstration* as currently used in *RD&D* provides not only for the test and evaluation (T&E) of a system or technique, but also a practical demonstration of the system or technique to potential users. The latter function can significantly contribute to the commercialization process.

PRELIMINARY ANALYSIS OF AN OPTION FOR THE FEDERAL PHOTOVOLTAIC UTILIZATION PROGRAM (FPUP)

A. KEY FINDINGS

The primary benefit of the Federal Photovoltaic Utilization Program (FPUP) would be to stimulate the accelerated establishment of a viable, highly competitive, photovoltaic (P/V) Industry. This industry would be capable of supplying the private sector with a major source of clean, non-depletable electrical energy (e.g., for residential, commercial, industrial requirements). As a secondary benefit, the Federal government is expected to realize significant net cost savings. Also, the government should benefit from the stimulation of a new mode of operation where fuel efficient, life cycle cost effective products are routinely procured. This FEA commercialization program, in conjunction with an aggressive ERDA R&D effort, should ensure the rapid development of a large U.S. photovoltaics industry.

The FPUP option analyzed in this report would consist of a series of federal procurements resulting in the installation of 152 megawatts peak (MWp) of photovoltaic arrays over a five year period. Photovoltaic arrays procured under the program were assumed to be used for power systems that could replace up to 20 percent of the gasoline powered generators used by the DoD. Estimated benefits are listed in Exhibit 1. All costs and benefits were estimated relative to a baseline (no photovoltaic power system utilization) case. Costs are provided in 1975 constant dollars; they should be escalated by 25 to 30 percent to represent 1979 dollars.

This option could result in a gross cost benefit of two billion dollars to the Federal Government for an investment of less than one-half billion dollars (i.e., net cost savings of $1.5 billion). These gross cost benefits would occur over a 25 year period (5 years for program plus 20 year equipment life) and would result from reduced operation, maintenance, and fuel outlays for conventional DoD power systems. If net cost savings for each buy are discounted at a 10 percent annual rate to the years of P/V system delivery, then net discounted cost benefits of $484 million would accrue to the Federal government. Direct fuel savings to DoD are expected to be relatively small--one million barrels per year. However, substantial indirect fuel savings could be provided by expanded use of life cycle effective power systems within DoD and the potential for exponential market growth in the private sector.

YEAR	ARRAY CAPACITY INSTALLED (MWp)	ASSUMED UNIT ARRAY PRICE ($/Wp IN 1975 DOLLARS)	DIFFERENTIAL GOVT CASH FLOW* (MILLIONS OF 1975 DOLLARS)	ANNUAL FUEL SAVINGS (MILLIONS OF GAL)	DISCOUNTED VALUE OF BENEFITS (MILLIONS OF 1975 DOLLARS)***	
1979	7	3.50	-33	–	484	45
1980	20	2.50	-66	3		148
1981	40	1.80	-81	11		126
1982	50	1.25	-81	29		127
1983	35	.75	24	44		38
1984	0	–	105	55		0
1985	0	–	102	↓		0
1986	0	–	96**	↓		0

*DIFFERENTIAL CASH FLOW = ANNUAL OPERATING AND MAINTENANCE (O&M) COST SAVINGS [illegible] ANNUAL COST OF P/V POWER SYSTEMS INSTALLED UNDER FPUP; O&M COST SAVINGS RESULT FROM REPLACING SMALL GENERATORS WITH P/V POWER SYSTEMS.

**PROGRAM PAYBACK ACHIEVED; THE CASH FLOW BENEFIT TO THE GOVERNMENT WOULD REMAIN AT APPROXIMATELY THIS ANNUAL LEVEL OVER THE LIFE OF THE INSTALLED P/V POWER SYSTEMS.

***20 YEAR TIME HORIZON, 10% DISCOUNT RATE, BENEFITS RESULTING FROM INSTALLATIONS DURING SPECIFIED YEAR ONLY

Exhibit 1. Benefits Under the Option of Replacing Small Gasoline Powered Engine Generator Sets with P/V Systems

B. BACKGROUND

1. Present Status of the Photovoltaics Industry

The present U.S. photovoltaics industry provides energy sources for a variety of remote site and portable equipment applications. However, market growth, and in turn, industry growth, is constrained by the use of handcrafted production techniques and the resulting high price of the P/V arrays. A range of present applications is illustrated by the list in Exhibit 2. Also, photographs of two currently functioning systems are included.

A P/V power system generally consists of an array, an energy storage system (battery) with control circuitry, and an inverter to convert the DC power produced by the array to AC. The array converts sunlight to electricity that can either be used directly or stored in a battery for later use. The total system price includes the prices of each component plus the installation cost. The rating of the solar cells in an array is measured in peak watts (Wp). This represents the power output of the cell under full sun conditions.

Presently communications equipment and corrosion protection equipment in remote locations provide the major terrestrial applications of photovoltaic power systems. Systems as large as 3.5 KWp have been installed as power sources for remote communications facilities. These systems are quite costly at today's prices of $12-30/Wp (depending upon the volume of the buy and special system features). However, they are often cost effective for remote site applications due to the high cost of supplying conventional power, e.g. installing electric power lines -- $10,000 - $50,000/mile -- or using generators.

The DoD is also utilizing photovoltaic power systems. One example is provided by the Range Measurement System (RMS-2). It is a radio ranging system that is used to provide target location data at military test sites. RMS-2's that incorporated solar power systems were initially installed in the field during 1975. They are currently used by both the Army and the Air Force. P/V powered RMS-2 stations are currently operational at two Army sites: Yuma Proving Ground and Fort Hunter-Ligget; and one Air Force site: Edwards AFB (Dugway-Wendover Area).

Total 1976 worldwide P/V deliveries were estimated to be 380-400 KWp (installations in non-communist countries only). This total included primarily private sector buys plus a small volume of government buys for terrestrial applications by DoD, the Department of Transportation, the Energy Research and Development Administration and other agencies, and about 50 KWp for space applications. Approximately two thirds of the total worldwide deliveries were for U.S. usage. An estimated 330-350 KWp of array capacity were manufactured in the U.S. in 1976, and current production capacity is rapidly expanding in 1977. Industry capacity, assuming FPUP is initiated, is expected to be capable of expanding at a rate greater than required by the FPUP purchase option plus an expanding private sector market. Current production is a handcrafted operation due to the small size of present markets. Thus unit array costs and prices are extremely high. It is a purpose of FPUP to stimulate industry to employ mass production techniques by creating a large, guaranteed market. This large market would permit mass production techniques to be employed.

RMS 2
A STATION

CALIFORNIA HIGHWAY PATROL REMOTE MICROWAVE AND
VHF REPEATER STATION

PRESENT P/V APPLICATIONS

MARKING & WARNING DEVICES

- AIRPORT LIGHTING
- OBSTRUCTION/HAZARD LIGHTS
- OFFSHORE NAVIGATION BUOYS
- ONSHORE NAVIGATION SYSTEMS
- OFFSHORE PLATFORM NAVIGATION AIDS
- RAILROAD CROSSING SIGNALS
- HIGHWAY SIGN DEFROSTERS

CORROSION PROTECTION

- PIPELINES
- WELL HEADS & CASINGS
- HIGHWAY BRIDGES

MONITORING & SENSING DEVICES

- INTRUSION ALARMS
- POLLUTION MONITORS
- WEATHER MONITORS
- SNOW/RAIN GAUGES
- FLOOD MONITORS
- OCEANOGRAPHIC DATA PLATFORMS

COMMUNICATION EQUIPMENT

- PORTABLE RADIOS
- REPEATER STATIONS
- TELEPHONE CALL BOXES
- TELEMETRY
- CC & REMOTE TV

CONSUMER PRODUCTS

- WATCHES
- CALCULATORS
- BOATING APPLICATIONS
- FLASHLIGHTS
- POCKET PAGING SYSTEMS

MISCELLANEOUS P/V APPLICATIONS

- WATER PUMPING STATIONS
- SPACE/SATELLITE APPLICATIONS
- MILITARY TEST SITE INSTRUMENTATION
- GOVERNMENT BUYS

INDUSTRY STATUS

1976 DELIVERIES

U.S.	–	270 KWp
FOREIGN (NONCOMMUNIST COUNTRIES)	–	110-130 KWp
TOTAL	–	380-400 KWp (BOM/SOLAREX EST.)

1976 ARRAY PRICES

1976 ERDA BUY – $15.50/Wp (~ 14.00 IN 1975 DOLLARS)
LOWER BIDS EXPECTED FOR NEW BUYS
SMALL PURCHASES – $15-30 OR MORE

Exhibit 2. Present P/V Power Systems Market

2. Description of the Federal Photovoltaic Utilization Program

FPUP was designed to accelerate and assure the development of a viable U.S. photovoltaics industry. Such an industry would become a significant future source of electrical energy for the U.S. Exhibit 3 provides a brief FPUP description and summarizes some of the considerations in the design of program options.

The FPUP initiative was based on Title II of S 672 and HR 7629 (95th Congress). This legislation called for the establishment of a Federal Photovoltaics Utilization Program. The basic photovoltaics acquisition option analyzed in this report was based on a number of assumptions: a five year program; a cumultive procurement of 152 MWp; and multi-year contracting authority. It was assumed that the systems acquired under the program would be utilized primarily by the DoD, but other Federal agencies are also expected to participate. Annual program status reports would be provided to Congress, and the administrator would be responsible for ensuring that P/V power systems installed under the program did not interfere with defense-related activities.

Several considerations are important in the overall program design. One is the optimal sizing and duration of the buy. A small, short duration buy would have a limited stimulatory effect on the industry. On the other hand, an extremely large, poorly phased procurement might overstress industry and make it difficult for the DoD and other participating Federal agencies to effectively utilize P/V power systems procured under the program.

The present study did not identify a precise quantitative optimal buy size. However, the buys were designed to be large enough to support the early implementation of mass production lines in each of three to five companies. (This was based on the lowest capacity -- 2.5 to 3.5 MWp/year -- mass production process described in published studies, Ref.7). Thus, following a smaller delivery in the initial (startup) year, the buy volume should grow to 10-20 MWp in the second year. Rapid continued increases in size would be necessary to support industry business volume growth until a rapid takeoff of commercial sales occurred. (See Section F.3)

The program must also include expenditures for all major cost factors listed in Exhibit 3. In particular, the P/V system includes the cost of the array, hardware and power conditioning, storage batteries, and installation. Additional front-end funding may be required for procurement incentive clauses, production engineering, and systems engineering for the products. These latter expenditures would be required, especially if the program duration was less than the assumed five years.

Finally, a number of potential applications of P/V power systems could be considered under the program. *One option* would be to substitute P/V power systems for a fraction of the DoD's small gasoline driven engine generator sets. This option was selected for detailed analysis in the next two sections. Examples of other possible P/V utilization options -- both DOD and non-DOD -- are listed in Exhibit 3. This particular option was found to offer large direct benefits to the Federal Government. However, other options may offer greater total national value.

PROGRAM OBJECTIVES

- ACCELERATE ESTABLISHMENT OF A VIABLE HIGHLY COMPETITIVE P/V INDUSTRY INFRASTRUCTURE CAPABLE OF:
  - PRODUCING LOW COST, RELIABLE P/V SYSTEMS
  - APPLYING NEW TECHNOLOGY AS DEVELOPED
  - DEVELOPING WIDE RANGE OF P/V PRODUCTS
  - ESTABLISHING/MAINTAINING MARKETING CHANNELS
- PERMIT INITIAL PENETRATION OF LARGE SCALE DISPERSED (I.E., RESIDENTIAL/COMMUNITY) MARKETS FOR CERTIAN APPLICATIONS (E.G., COOLING PEAK LOAD SHAVING) IN CERTAIN REGIONS BY 1983
- STIMULATE GENERAL USE WITHIN THE FEDERAL ESTABLISHMENT OF LIFE CYCLE COSTING AND INNOVATIVE PROCUREMENT METHODS
- SUPPORT OVERALL ACCELERATED COMMERCIALIZATION OF PHOTOVOLTAICS TO PROVIDE A COST EFFECTIVE MAJOR U.S. SOURCE OF ELECTRICITY

ADMINISTRATIVE REQUIREMENTS

- DEPARTMENT OF ENERGY (RESOURCE APPLICATIONS/COMMERCIALIZATION (FEA) AND RESEARCH, DEVELOPMENT, TEST AND EVALUATION FUNCTIONS (ERDA))
  - ESTABLISH FPUP COMMERCIALIZATION PROJECT. CONDUCT AS PART OF OVERALL P/V COMMERCIALIZATION PROGRAM
  - DEVELOP SYSTEM EVALUATION AND PROCUREMENT INCENTIVES PROGRAM
  - REPORT ANNUALLY TO CONGRESS
  - PRESCRIBE RULES/REGULATIONS
  - ESTABLISH ADVISORY COMMITTEE COMPRISED OF FPUP PARTICIPATING AGENCIES
  - ACCELERATE OVERALL P/V R&D PROGRAM
  - PROCEED WITH NECESSARY ACTIONS TO ASSURE AVAILABILITY OF LOW COST P/V MATERIAL (E.G., SUPPORT SILICON PILOT PLANTS/NEW METALLIC SILICON PROCESS, ETC.)
  - SUPPORT AND COORDINATE EARLY FPUP SYSTEMS ENGINEERING
  - SUPPORT TECHNOLOGY TRANSFER APPLICATIONS ENGINEERING IN CONJUNCTION WITH FPUP SYSTEMS ENGINEERING
  - FULLY UTILIZE FPUP PROGRAM TO ADVANCE MANUFACTURING TECHNOLOGY
- FPUP PARTICIPATING AGENCIES (AGENCIES WHICH WOULD UTILIZE OR FACILITATE THE USE OF, P/V SYSTEMS - - E.G., DOD, DOT, ETC.)
  - ESTABLISH USE OF LIFE CYCLE COSTING & PERFORMANCE PURCHASING
  - IDENTIFY APPLICATIONS
  - PREPARE AGENCY PLAN TO USE, OR FACILITATE USE OF P/V SYSTEMS, AS PART OF BOTH
    - - - FPUP BUYS
    - - - SUSTAINING MARKET

KEY FEATURES OF THE EVALUATED FPUP OPTION

- MINIMUM FEDERAL MULTI YEAR COMMITMENT, DURING THE FIRST FIVE YEARS OF THE PROGRAM, ADEQUATE TO ACHIEVE THE PROGRAM OBJECTIVES (E.G., AT LEAST 152 MWP PURCHASED IN FIRST FIVE YEARS)
- ANNUAL PURCHASE LEVEL SUBSTANTIAL ENOUGH TO PERMIT LOW COST PRODUCTION TECHNIQUES FOR A NUMBER OF COMPANIES
- MULTI YEAR CONTRACTING AUTHORITY
- AFTER LOW COST PRODUCTION TECHNIQUES INITIATED, ALL SYSTEMS PROCURRED WOULD BE LIFE CYCLE COST EFFECTIVE; OVERALL PROGRAM COST EFFECTIVE
- $500 MILLION NET DISCOUNTED PRESENT VALUE BENEFIT
- RAPID DECLINE IN PRICE DEPENDENT ON PURCHASE VOLUME

VARIBALES IN DESIGN OF PROGRAM OPTIONS

- BUY SIZING AND DURATION - - EXAMPLES OF ALTERNATIVE MULTI-YEAR COMMITMENTS
  - 152 MW$_p$ PROGRAM BUY OVER A FIVE YEAR PERIOD (1)
  - *INITIATE* LOW COST PRODUCTION TECHNIQUES WITH FIRST MULTI YEAR BUY (E.G., 32 MEGAWATTS). PROVIDE PRESIDENT AND CONGRESS WITHIN A SPECIFIED TIME, RECOMMENDATION FOR FULL MINIMUM MULTI-YEAR COMMITMENT ADEQUATE TO *SUSTAIN* INDUSTRY GROWTH AND MEET FPUP GOALS.
  - 200 MW$_p$ FEDERAL BUY (FPUP PLUS DEMONSTRATIONS) OVER A SIX YEAR PERIOD)
  - OTHER
- PROCUREMENT PROCEDURES
- COST FACTORS
  - PRODUCTION ENGINEERING/EQUIPMENT
  - SYSTEMS ENGINEERING
  - P/V SYSTEMS
    - ARRAY
    - HARDWARE AND POWER CONDITIONING
    - ENERGY STORAGE (BATTERIES)
    - INSTALLATION
  - OPERATIONS AND MAINTENANCE
  - PROCUREMENT INCENTIVE CLAUSES
- APPLICATIONS OPTIONS
  - SUBSTITUTION FOR SMALL GENERATORS (1.5-10 KWe) (1)
  - POWER SOURCES FOR REMOTE TEST SITE INSTRUMENTATION
  - BASE HOUSING POWER
  - POWER SOURCES FOR COMMUNICATIONS APPLICATIONS
  - HIGHWAY LIGHTING (DOT)
  - EXPORT INITIATIVES (FEA, US AID, DOC)

(1) OPTION ANALYZED IN REPORT

Exhibit 3. Program Description and Consideration in Program Design

C. BASIC ASSUMPTIONS UNDERLYING THE OPTION ANALYZED

1. Assumptions About Buys

The photovoltaic array purchases were assumed to be made in three separate buys. Each buy was assumed to result in the delivery of photovoltaic arrays over a 3-year period. Total deliveries and costs of each buy were constrained to be less than or equal to $100 million. (This was a feature of a version of S 672, Title II, 95th Congress.) The top portion of Exhibit 4 summarizes the assumed sequencing of deliveries under each buy, and the graph at the bottom of the exhibit shows possible future unit array prices as a function of time. In particular, the FPUP purchase option provides for a strong, multi-year Federal commitment - a first buy of 32 MWp with deliveries phased over 3 years, and a 152 MWp five year commitment. This first buy would be followed at one year intervals by second and third buys of 50 and 70 MWp, respectively.

It is anticipated that the large procurements resulting under this program would permit the photovoltaics industry to employ mass production techniques. Thus, unit array costs would decline substantially from today's handcrafted price of $15.50/Wp ($14 in 1975 dollars) -- the *average* price for the 1976 ERDA buy for photovoltaic arrays -- to an average of $2/Wp to $4/Wp for the first year's buy under FPUP. Further price reductions would be expected as mass production techniques were improved. These price assumptions are consistent with the results of ERDA, FEA, and NASA production system studies and historical experience for other semiconductor industry products.

The first procurement is assumed to be scheduled for 1978, with delivery and installation of equipment starting in 1979. Unit array cost assumptions --labeled "weighted av." in the exhibit -- were developed on the basis of industry estimates. They were generally higher than the prices listed at the bottom of the exhibit and labeled "probable". Price assumptions represent an average value for each buy. Thus the first deliveries of the year are expected to have a higher production cost than the last deliveries, and industry would be expected to average these costs when committing to annual delivery prices under multi-year contracts. This reflects the assumption that lead time requirements for production capacity expansion and time requirements for product engineering development will cause 1979 deliveries to be concentrated at the end of the year. Mass production techniques introduced to meet program requirements are assumed to produce the initial price decline.

The graph at the bottom of the exhibit illustrates the possible effect of the buy on photovoltaic array prices. The top line represents a baseline price trajector linking today's price with the 1986 ERDA goal of $.50/Wp (in January 1, 1975 constant dollars). Such a price decline is consistent with the relationship between cumulative production experience and unit production costs in the semiconductor industry. (See Section F.2.) Generally, as cumulative production volume has increased for semiconductor products, innovations in the production process and product modifications have resulted in unit production cost declines.

BUY (OBLIGATION)	UNIT COST ($/W_p)	DELIVERY (MW_p) 1979	1980	1981	1982	1983	TOTAL PROCURED (MW_p)	ARRAY COST ($ MILLION)*
FIRST (1978)	3.50	7					7	24.5
	3.00		10				10	30.0
	2.50			15			15	37.5
SUBTOTAL		7	10	15			32	92.0
SECOND (1979)	2.00		10				10	20.0
	1.75			15			15	26.3
	1.5				25		25	37.5
SUBTOTAL			10	15	25		50	83.8
THIRD (1980)	1.25			10			10	12.5
	1.00				25		25	25.0
	0.75					35	35	26.3
SUBTOTAL				10	25	35	70	63.8
TOTAL		7	20	40	50	35	152	239.5***
WEIGHTED AV PRICE ($/W_p)		3.50	2.50	1.00	1.25	0.75		
MID-YEAR PRICE AT DELIVERY		3.25**	2.45	1.35-1.45	0.80-1.00	0.50-0.80		

*ALL COSTS IN 1975 CONSTANT DOLLARS
**YEAR END PRICE
***FOR SYSTEM COST REFER TO EXHIBIT 4

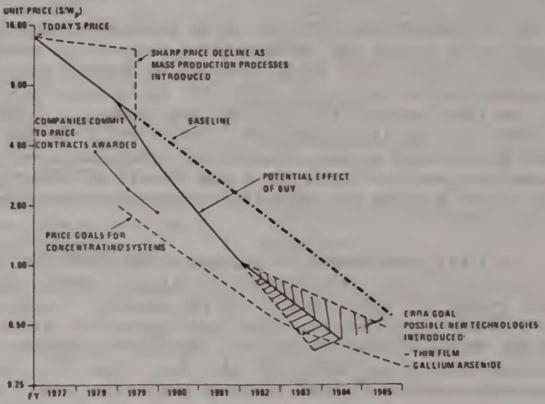


Exhibit 4. Assumed Sequencing of Buy and Possible Impacts on Photovoltaic Array Prices

The same type of cumulative production volume unit cost relationship is expected to apply to solar cells. Assuming that production volume with the buy is additional production relative to the baseline (i.e., no FPUP) case, annual production with FPUP buy *equals* annual buy volume *plus* annual baseline volume. In this case, the price versus time line labeled "potential effects of buy" would describe the price impacts of the buy. Before mass production processes are introduced, unit cost declines for handcrafted arrays may follow the pattern shown by the dashed line in the upper lefthand corner of the graph. The crosshatched area on the graph shows the possible effect of further industry stimulation caused by rapid price reductions.

2. Assumed DoD Applications of Photovoltaics Under One Program Option

It was assumed that the DoD would replace up to 20 percent of the gasoline powered generators in their present inventory with photovoltaic power systems. These generators are currently used as power sources for area lighting, communications equipment, and for other uses. Exhibit 5 lists the assumed characteristics of this generator inventory.

For purposes of this analysis, only 20 percent of the current inventory was assumed to be replaceable by photovoltaic power systems. Candidates for replacement would include generators for floodlights, remote communications applications, and power for remote test site instrumentation. Only small, gasoline engine driven generators in the 1.5 to 10 KWe range were considered for replacement. These generators are characterized by especially high operating and maintenance costs per kilowatt hour delivered. Applications options--other than small, frequently used gasoline generators--such as those mentioned in Section B.2 might also be considered in the design of the utilization program.

The remaining 80 percent of the inventory includes generators used infrequently. Examples include applications such as standby power or equipment used in the field only 6 or 8 weeks per year. High first costs for photovoltaic power systems would limit their use in such applications. Hence, generators used in this mode of operation were not candidates for substitution during the initial buy. However, as unit prices decline, photovoltaic power systems should also become cost effective energy alternatives for some of these applications.

The conventional generator cost and fuel consumption data given in Exhibit 5 were based on an assumed 2,000 hours per year of operation at a load factor of one-half. These assumptions, operating and maintenance costs, and fuel consumption data were provided by DoD MERADCOM. Generator operations and maintenance costs consist of fuel cost *plus* cost of major overhauls. Costs not considered include the initial purchase cost of the engine-generator sets, training costs for mechanics, and costs of installing fuel tanks. Thus, the analysis is conservative since actual conventional system costs would be higher than stated.

Characteristics of the photovoltaic power systems designed to replace the generators are also described in Exhibit 5. The systems would consist of an array, power conditioning, support structure, and a storage battery. The arrays and batteries were sized to provide operating power for an 8-hour period consisting of 50 percent daytime and 50 percent nighttime use. Actual duty cycles would vary from application to application, and system size would vary accordingly. This duty cycle represents an average value for a variety of specific applications. Array size requirements would vary linearly with the operating power and operating period. Additional battery storage capacity was included to keep the average daily discharge less than 40 percent of capacity, in order to ensure a 5-year battery life and provide energy for low sun days. Operating and maintenance expenses may be significant for the first P/V units procured under the Program. However, they were assumed to be negligible when averaged over the 5-year, 152 MWp buy.

GENERATOR OPERATING CHARACTERISTICS

- DUTY CYCLE – – 8 HRS/DAY FOR 5 DAYS PER WEEK AND 52 WEEKS/YEAR
- FUEL – – GASOLINE
- START TIME – – 0400 (I.E. 50% DAYTIME USE· 50% NIGHTTIME USE)
- LOAD FACTOR – – .8

ASSUMED P/V ENERGY SYSTEM CHARACTERISTICS

- OVERALL SYSTEM EFFICIENCY – – .69 (EXCEPT ARRAY)
- DESIGN INSOLATION – – 400 L/D (AFTER TILT ADJUSTMENT)
- LIFETIME
  - ARRAY AND POWER CONDITIONING – – 20 YEARS
  - BATTERY STORAGE – – 5 YEARS
- SYSTEM COMPONENTS
  - P/V ARRAY
  - POWER CONDITIONING
  - SUPPORT STRUCTURE
  - STORAGE BATTERY

GENERATOR RATING / CHARACTERISTICS	1.5 KW$_E$	3 KW$_E$	5 KW$_E$	10 KW$_E$
CURRENT INVENTORY (1000's)[1]	70	57	38	49
20% OF INVENTORY (1000's)	14	11.4	7.6	9.8
O&M COSTS/KWHR OF OPERATION[2]	1.63	.93	.74	.47
ASSUMED KWHR/YR OF OPERATION	1560	3120	5200	10400
ASSUMED KWHR/DAY	6	12	20	40
ANNUAL O&M COSTS/GENERATOR	2545	2900	3850	4900
ASSUMED FUEL CONS. (GAL/KWHR)[2]	.5	.57	.36	.42
ANNUAL FUEL CONS. (GAL/YR)	780	1780	1870	4370
P/V SYSTEM	▨	▨	▨	▨
ASSUMED ARRAY RATING	1.9 KW$_p$	3.8 KW$_p$	6.3 KW$_p$	12.6 KW$_p$
SYSTEM COSTS (HARDWARE, POWER CONDITIONING, ENGINEERING)[3]	1900	3800	6300	12600
ANNUAL P/V O&M COST[4]	NEG	NEG	NEG	NEG
BATTERY SIZE (KWHR)	9	18	30	60
BATTERY COST (INSTALLED AT SITE)[5]	450	900	1500	3000
BREAKEVEN ARRAY PRICE ($/W$_p$)	10.00	6.05	3.70	1.80

NOTE ALL COSTS ARE IN 1975 CONSTANT DOLLARS

[1] DATA PROVIDED BY THE DOD MOBILITY EQUIPMENT RESEARCH AND DEVELOPMENT COMMAND (MERADCOM)

[2] DATA PROVIDED BY THE DOD TROOP SUPPORT COMMAND

[3] ASSUMED TO BE $1/Wp. ACTUAL PRICES ARE EXPECTED TO BE HIGHER AT THE BEGINNING OF THE PROGRAM AND LOWER AT THE END. THIS IS PARTICULARLY TRUE OF SYSTEMS ENGINEERING COSTS.

[4] ASSUMING HIGH RELIABILITY OF MOST EQUIPMENT INSTALLED OVER LIFE OF PROGRAM

[5] BATTERIES ASSUMED TO BE REPLACED AT FIVE YEAR INTERVALS. INSTALLED COST IS $50/KWHR

Exhibit 5. Assumed Characteristics of the DoD Engine Generator Sets to be Replaced by Photovoltaic Power Systems

Both the P/V power systems and the gasoline generators being replaced would require additional generators as backup units. Generators used as backup units for the P/V power systems would eventually be replaced by adding additional battery storage capacity. This replacement would occur after the reliability of the P/V systems was demonstrated. Prior to this total replacement, the cost of maintaining backup generators was assumed to be roughly equal for the conventional and P/V systems. Thus these costs were assumed to balance each other in the analysis.

Breakeven array prices were estimated on the basis of life cycle costs over a 20-year system lifetime. The breakeven price for the P/V array is defined to be the unit array price at which the discounted value of the life cycle costs for the P/V system and corresponding conventional system are equal. Life cycle costs were discounted at a 10 percent annual rate, and the real costs for all system components were assumed to remain constant in 1975 dollars. Note that these breakeven costs were generally much higher than the assumed average array prices for the FPUP buys.

D. COSTS AND BENEFITS OF THE PROGRAM

1. Costs and Benefits to the Federal Government

The Federal Government is expected to realize significant cost benefits and fuel savings under this program. Direct discounted (gross) present-value cost benefits of about one billion dollars would be realized under the evaluated FPUP option. An investment of less than one-half billion dollars would be required to achieve these benefits (i.e., a net discounted present value savings of almost $500 million). Substantial, less easily quantified national benefits would also be received. These benefits are discussed in Section D.3. Exhibit 6 provides different perspectives on these benefits. In each case, costs and benefits for the program were estimated relative to a "no purchase of photovoltaics" case. Generators having the highest operating and maintenance costs per kilowatt hour were assumed to be replaced first.

The top half of Exhibit 6 provides estimates of annual cash flows and fuel savings under the proposed program. Initially, greater annual expenditures would be required due to the high investment costs of photovoltaic power systems. However, savings in operating costs would increase rapidly; and annual savings of $100 million per year (1975 dollars) are estimated to result upon completion of the purchase program. These savings would continue for the life of the installed photovoltaic power systems. Also, direct annual fuel savings were estimated to exceed over one million barrels of oil per year. Reduction in the use of fuel has the added advantage of reducing the logistics burdens of resupplying units in the field.

Although delivery and installation of photovoltaic power systems would be expected to be spread over the entire year, expenses were included for the full annual operating and maintenance costs for the gasoline powered generators to be replaced during the year. Thus, benefits of the program were probably understated. Exhibit 6 shows the net discounted value of the savings to the Government resulting from each annual buy. A 10 percent discount rate and a 20 year time horizon were assumed.

Cost benefits resulting from each annual buy have been discounted to the year of the buy and expressed in 1975 constant dollars. These discounted cost benefits sum to 484 million. If all of these benefits are discounted back to the common year of 1979 and summed, then the combined value of net benefits of over 400 million is obtained.

Net cost benefits would increase if DC power could be used in the solarized applications. No inverter would be required to convert DC produced by the array to AC. Consequently, system efficiency would be about 15 percent greater and array size could be reduced by 15 percent with a corresponding reduction in system cost.

Also, prices are production volume sensitive. Hence, the accelerated production volume (FPUP *plus* induced non-FPUP buys) resulting from FPUP buys could result in a more rapid photovoltaic array price decline than assumed. The net positive cost benefits could exceed the benefits reported here under these circumstances.

ANNUAL CASH FLOWS AND FUEL SAVINGS (COST IN 1975 CONSTANT DOLLARS)

	GEN RATING	1979	1980	1981	1982	1983	1984
GENERATORS REPLACED DURING YEAR	1.5	3,680	10,320				
	3		100	10,500	800		
	5				7,480	120	
	10					2,710	
CUMULATIVE GENERATORS REPLACED THROUGH PRIOR YEARS	1.5		3,680	14,000	14,000	14,000	14,000
	3			100	10,600	11,400	11,400
	5					7,480	7,600
	10						2,710
ANNUAL O&M COSTS FOR GENERATORS REPLACED THROUGH PRIOR YEAR (1000's OF 1975 DOLLARS)	1.5		9,000	34,000	34,000	34,000	34,000
	3			280	30,000	32,000	32,000
	5					28,000	28,000
	10						13,000
	TOTAL		9,000	34,280	64,000	94,000	107,000
P/V SYSTEM INVESTMENT COST (1000's OF 1975 DOLLARS)	1.5	33,000	73,000				2,000[2]
	3		1,500	125,000	7,600		
	5				117,000	1,500	
	10					68,000	
	TOTAL	33,000	74,500	125,000	125,000	70,000	2,000[2]
DIFFERENTIAL ANNUAL CASH FLOW FOR GOVERNMENT (1000's OF 1975 DOLLARS)		-33,000	-66,000	-91,000	-61,000	+24,000	+105,000[3]
TOTAL ANNUAL FUEL SAVINGS (1000's OF GALS)			2,800	10,700	28,600	43,500	55,100

[1] SYSTEM COST EQUALS ARRAY COST PLUS HARDWARE COSTS PLUS POWER CONDITIONING COST PLUS BATTERY STORAGE COST PLUS BASIC SYSTEM ENGINEERING COSTS

[2] BATTERY REPLACEMENT COST FOR ALL SYSTEMS INSTALLED IN 1979

[3] THE CASH FLOW BENEFIT TO THE GOVERNMENT WOULD REMAIN AT APPROXIMATELY THE 100 MILLION LEVEL OVER THE NEXT 15 YEARS.

PRESENT VALUE OF BENEFITS (DISCOUNTED AT 10% ANNUAL RATE OVER 20 YEAR SYSTEM LIFE)

	GEN RATING	1979	1980	1981	1982	1983	1984
ARRAY BREAKEVEN PRICE MINUS BUY PRICE ($/Wp)	1.5	6.50	7.50				–
	3		2.55	3.15	3.80		
	5				2.45	2.95	
	10					1.05	
GENERATORS REPLACED DURING YEAR	1.5	3,680	10,320				–
	3		100	10,500	800		
	5				7,480	120	
	10					2,710	
DISCOUNTED VALUE OF BENEFITS (20 YEAR TIME HORIZON) (1000's OF 1975 DOLLARS)	1.5	45,400	147,100				–
	3		970	125,700	11,600		
	5				115,500	2,200	
	10					35,900	
TOTAL PRESENT VALUE OF BENEFITS FOR UNITS INSTALLED IN EACH YEAR (1000's OF 1975 DOLLARS)[1]		45,000	148,000	126,000	127,000	38,000	–

[1] COSTS BENEFITS ARE DISCOUNTED OVER A 20 YEAR TIME HORIZON TO YEAR OF SYSTEM INSTALLATION

Exhibit 6. Annual Cash Flows, Fuel Savings, and Discounted Annual Benefits Resulting From a Photovoltaic Power Systems Utilization Option

2. Sensitivity of Results to Alternative Assumptions

The magnitude of the direct benefits received by the Federal Government is highly sensitive to future economic conditions, the operating cycles of the equipment being replaced with photovoltaics, and the characteristics of the photovoltaic power systems (price, efficiency, O&M costs, etc.) Certain key factors influencing the magnitude of these benefits include the average number of days per year of operation for the equipment; the assumed escalation in the real cost of fuel and operating and maintenance expenses for conventional engine generator sets; and the cost of the engine generator sets. Exhibit 7 graphically illustrates the effects of these factors on the estimated value of the net benefits. The scale on the right hand column shows the sum of the net benefits discounted to the years of installation (i.e., "present value"). The left hand column shows the value of net program benefits discounted to 1979. (costs in 1975 dollars.)

The average number of days per year of operation for the generators being replaced has a significant impact on the total benefits. This results from the fact that photovoltaic power systems have high first costs but negligible operating and maintenance expenses. On the other hand, operating and maintenance expenses are very high for gasoline engine-generator sets. Thus, total costs increase rapidly with increased usage for engine-generator sets. Costs associated with photovoltaic power systems remain roughly constant. These factors enhance the attractiveness of photovoltaic power systems as replacements for engine-generator sets that are subject to frequent use.

If it is assumed that the photovoltaic power systems lead to the actual replacement of engine-generator sets, then the dashed line in the exhibit represents the true value of the cost benefits. Cost benefits associated with this line are based on assumed replacement of the engine-generator sets at 8-year intervals. Actual replacement is expected to occur as photovoltaic power systems demonstrate their reliability. Thus this dashed line may provide a truer measure of program benefits.

Benefits reported earlier were based on no escalation in the real cost of purchasing fuel or operating and maintaining engine-generator sets. If fuel and O&M costs for the generators are assumed to increase at an annual rate of two percent above the general inflation rate, then net benefits illustrated by the upper set of lines on the graph should result.

Sensitivity analyses were also conducted to test the effects of other assumptions. For example, if net benefits for each year of the buy were discounted over a 10-year time horizon rather than for 20 years, then, on the average, their value would be cut by one-half. However, use of photovoltaics for these applications would still be cost effective.

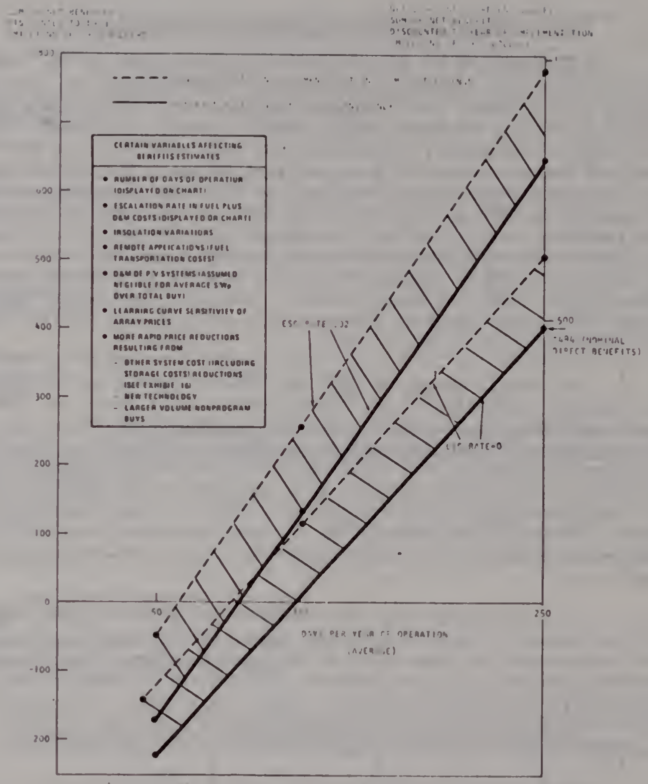


Exhibit 7. Sensitivity of Net Discounted Cost Benefits to Variations in the Assumed Number of Days of Operation Per Year, the Escalation Rate in the Real Cost of Conventional Energy, and the Inclusion of Equipment Cost in the Benefits Estimates

Other assumptions that would affect the magnitude of the direct program benefits are summarized in the box in Exhibit 7. These include the effects of substantial operating and maintenance costs for systems procured early in the buy (O&M costs were assumed to be negligible when averaged over the entire buy). Such costs would reduce the magnitude of early program benefits. On the other hand, more rapid reductions in array prices than those envisioned in the analysis--resulting from new P/V technologies or more rapid implementation of advanced production technologies--could increase program benefits beyond those listed.

3. National Benefits of the Federal Photovoltaics Utilization Program

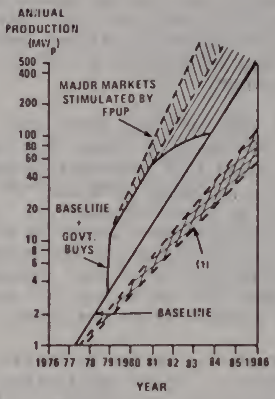
FPUP offers several potential benefits to the Nation and to the DoD. These national benefits, which are in addition to certain substantial, direct cost benefits assessed in Section D.1, might fully justify implementation of FPUP. Over the long term, these benefits would result from accelerating the development of the P/V industry. Accelerated development could in turn provide; a major non-polluting source of electrical power; reduced dependence on foreign energy sources; and other significant national advantages. Exhibit 8 summarizes potential program benefits and lists major sustaining markets likely to be stimulated by FPUP.

Qualitatively, potential impacts of FPUP on total production volume are shown on the graph in Exhibit 8. The baseline production volume was derived by interpolating between the estimated 1976 photovoltaic panel production of 330-350KWp in the U.S. and ERDA's suggested 1986 goal of 500 MWp. The buy is assumed to be in addition to normal production. In practice, it would stimulate even more rapid industry development by creating a larger industrial base. The crosshatched area at the top of the graph shows the possible range of production volume impacts stimulated through the buy. In the absence of such stimulation, actual U.S. sales may fall below the baseline projection as shown by the area labeled (1) on the graph.

Several new applications offer a cumulative market potential of several thousand MWp (See Section F.4 for details). These applications include power systems for water pumping and power for corrosion protection of pipeline and well casings. Photovoltaic power systems are already being utilized in these applications. Virtually unlimited markets exist for certain residential application in the U.S.--e.g., cooling, peak load shaving. In lesser developed countries, lack of power grids and difficulties in maintaining engine-generator sets enhance the attractiveness of photovoltaic power systems for use in village: communications, irrigation, refrigeration, water purification, and other applications.

The rapid expansion of industry production capacity under the modified program could provide the benefit of accelerating development of these markets. Also, additional government P/V commercialization programs may be implemented concurrently with FPUP if even more rapid industry growth is desired. The combining of these commercialization programs should provide synergistic benefits.

Program benefits include advantages to the DoD such as reduced resupply logistics, high reliability, and silent operation. Disadvantages are caused by large physical system size and high initial cost. National social benefits would result from the favorable effects of P/V power systems on the nation's energy economy1. Photovoltaics would provide a clean, non-depletable energy source. This would benefit the U.S. by preserving some fossil fuels for other, higher uses (e.g., petrochemicals feedstocks), and it would save the value of subsidies on displaced conventional energy resources. These and other important benefits were discussed in a "Solar Heating and Cooling of Buildings (SHACOB) Commercialization Report"1 and "DoD Photovoltaic Energy Systems Market Inventory and Analysis."[2]



[1] LIKELY U.S MARKET SIZE IF NO MAJOR NEW COMMERCIALIZATION INITIATIVES (e.g. FPUP) UNDERTAKEN

P/V MARKETS LIKELY TO BE SIMULATED BY FPUP [1]

- PRESENT APPLICATIONS (SEE SECTION B1)
- MAJOR DOD APPLICATIONS
  - REMOTE RADAR SITES
  - REMOTE ISLAND SITES
  - REMOTE TEST SITES
  - MORE EXTENSIVE GENERATOR CONVERSION ~ 1,000 - 5,000 MW_p
- MAJOR U.S. APPLICATIONS (NON–DOD)
  - POWER FOR IRRIGATION AND WATER PUMPING – – SMALL PUMP MARKET (1-3HP) ALONE MIGHT USE 1000 - 5,000 MW_p
  - CORROSION PROTECTION OF PIPELINES AND WELL CASINGS 200 - 300 MW_p
  - AREA LIGHTING – – 60,000 - 110,000 MW_p
  - GENERATOR REPLACEMENT – 800 - 6,000 MW_p
  - REMOTE ORE PROCESSING
  - COMMUNITY/INDUSTRY ELECTRIC POWER SUBSTATIONS
  - TOTAL ENERGY SYSTEMS
- RURAL ELECTRIFICATION IN UNDERDEVELOPED COUNTRIES
  - POWER FOR IRRIGATION PUMPS ~ 1,000's OF MW_p
  - POWER FOR REMOTE VILLAGES ~ 100's OR 1000's OF MW_p (VIRTUALLY UNLIMITED)

[1] POTENTIAL MARKET IF PHOTOVOLTAIC POWER SYSTEMS ARE SUBSTITUTED FOR EXISTING ENERGY SYSTEM

ADVANTAGES TO DOD

(1) COST SAVINGS
(2) HIGH RELIABILITY AND LOW MAINTENANCE
(3) UNATTENDED OPERATION
(4) LONG LIFE
(5) SILENT OPERATION
(6) FOSSIL FUEL SAVINGS
(7) REDUCED RESUPPLY LOGISTICS
(8) NEARLY WORLDWIDE APPLICABILITY
(9) MODULAR CHARACTERISTICS

DISADVANTAGES TO DOD

(1) HIGH INITIAL COST
(2) LARGE PHYSICAL SIZE (RELATIVE TO CONVENTIONAL ENERGY SOURCES) WHEN DEPLOYED
(3) POWER OUTPUT PER UNIT ARRAY SIZE VARIES WITH LOCATION AND SEASON

POTENTIAL BENEFITS TO U.S.

(1) EXTREMELY COST EFFECTIVE MEANS OF PROVIDING PRODUCTION VOLUME NECESSARY TO MEET OR EXCEED FEDERAL P/V PRICE REDUCTION GOALS.
(2) NEAR TERM COST EFFECTIVE POWER SOURCE FOR REMOTE SITES
(3) POTENTIALLY SIGNIFICANT EQUIPMENT EXPORT
(4) REDUCED DEPENDENCE ON FOREIGN ENERGY SOURCES
(5) PROVIDES NON POLLUTING SOURCE OF ELECTRICAL POWER
(6) NON DEPLETABLE ENERGY SOURCE
(7) LARGE SCALE P/V USAGE WILL PRESERVE FOSSIL FUELS FOR HIGHER USES (E.G., PETROCHEMICAL FEED STOCKS)
(8) ACCELERATION OF OTHER TECHNOLOGY DEVELOPMENT SUCH AS ENERGY STORAGE
(9) SAVE NATION VALUE OF SUBSIDIES ON DISPLACED CONVENTIONAL ENERGY SOURCES

Exhibit 8. Major Markets Which Might be Stimulated by the Availability of Low Cost Photovoltaic Power Systems

E. OVERVIEW OF ISSUES

Implementation of the Federal Photovoltaics Utilization Program Option analyzed in this report would lead to well over a hundred-fold increase in solar array production in the short span of five years. The effect of resultant lowered prices on the rate of commercial market development should multiply this effect again. The overall result would be to force the maturation of the photovoltaics industry by an early, large purchase beyond the scale expected in a natural growth.

The following sections discuss the key issues associated with the rapid development of a photovoltaics market through the strategy of a large government purchase. In many ways the themes that appear and reappear in the discussion of key issues involve the central problem of timing and growth, and the responsiveness of institutions -- federal (legislative/executive), military, industrial and commercial -- to a new industrial technology maturing under pressure. Exhibit 9 summarizes the key issues addressed, and lists the subsections of Section F where the topics are discussed. The exhibit also lists the benefit/cost issue that was the topic of Section D.

The first set of issues relate to market size and industry capabilities. The initial focus is on the capability of industry to meet the program array price goals. This issue is addressed by examining the potential for cost reductions in each of the major steps in the silicon P/V array manufacturing process. An alternative approach is taken in Section F.2. There the effects of accumulated production experience on unit product cost is assessed for related semiconductor technologies. Both approaches support the contention that FPUP P/V array price assumptions are realizable. Other industry related issues are posed by the need to both maintain significant annual increases in business volume and to be assured of adequate sustaining P/V markets. Both of these conditions are required to assure active industry participation in FPUP.

Program related issues center on the design of procurement procedures and the choice of technologies to be purchased. Selection of appropriate procurement procedures is required to ensure that technological innovation is promoted. Also, care must be taken to promote competition within industry. On the other hand, the FPUP buys must be concentrated in a relatively small number of companies (three to five), in order to rapidly stimulate the introduction of mass production techniques for producing low cost P/V arrays.

Finally, issues related to DoD utilization are discussed. First the logistics resupply advantages of using photovoltaics with battery storage relative to conventional generators is evaluated. Then barriers to DoD utilization are explored. It is concluded that the normal equipment acquisition process, high first costs of P/V power systems, and other factors would greatly reduce the rate of DoD utilization of photovoltaics in the absence of FPUP.

SECTION(S) IN F WHERE ADDRESSED	ISSUE
1, 2	● ABILITY OF INDUSTRY TO MEET PROGRAM PRICE GOALS
	– USE OF EXISTING PROCESSES
	– EXPERIENCE IN ANALOGOUS INDUSTRIES
3	● CAPITAL AVAILABILITY /BUSINESS VOLUME REQUIREMENTS
4	● VIABILITY OF SUSTAINING MARKETS
	– DOD
	– NON-DOD
5	● CHOICE OF TECHNOLOGIES TO BE PURCHASED
	– FLAT PLATE
	– CONCENTRATING SYSTEM
6	● DESIGN OF PROCUREMENT PROCEDURES
	– PROMOTION OF FPUP GOALS (E.G. INNOVATION, COMPETITION, ACCELERATED COMMERCIALIZATION, ETC.)
	– SELECTION OF OPTIMUM COMBINATIONS OF PROCUREMENT INCENTIVES
	– IMPACTS ON INDUSTRY DEVELOPMENT
	– IMPACTS ON USER AGENCY
7	● EFFECTS OF MOBILITY REQUIREMENTS
8	● BARRIERS TO DOD UTILIZATION
	– TIME FOR EQUIPMENT ACQUISITION PROCESS
	– HIGH FIRST COST OF PRODUCT
SECTION D	BENEFITS AND COSTS OF PROGRAM
	– FEDERAL GOVERNMENT
	– NATION

Exhibit 9. Key Issues Addressed In This Study

F. DISCUSSION OF KEY ISSUES

1. Reasons for Confidence in Silicon Photovoltaic Array Price Reduction Assumption

a. Overview

Existing production technologies should provide silicon P/V array price reductions equal to or greater than the reductions assumed for the analysis. To understand the problems and prospects, for the low cost manufacture of solar arrays, each component in the production process must be understood. Exhibit 10 summarizes the steps in the production process. Also, reasons for selecting flat plate silicon arrays for analysis are listed.

The total manufacture of silicon photovoltaic solar arrays consists of three discrete steps. First, extremely pure silicon must be manufactured. This silicon, from whatever source, must be grown into crystals and cut into a shape suitable for inclusion into a photovoltaic panel. Finally, these blank "slices" or wafers of whatever shape or thickness must be activated, wired, and placed into order in solar arrays. More advanced production techniques might combine portions of these steps. Also, the degree of evolution in the production technology for each step will be influenced by the actual magnitude and duration of the FPUP purchase option.

The cost of the finished array is the cumulative cost of three processes. Currently, the three processes are relatively independent. Thus an analysis of industrial capacity to meet the quantity and price goals of FPUP must evaluate the technology for each process separately. This allows an estimate of the feasibility of the Program price goals, and identifies the specific barriers to those goals.

There are several reasons to focus this preliminary FPUP analysis on the use of fixed, flat plate silicon arrays. Most arrays currently deployed utilize this technology. Thus the Program can utilize the industry experience gained to date with the installation and utilization of P/V arrays. At the same time, the information provided in the next three sections indicates that this technology has the growth potential needed to achieve FPUP price goals.

Despite the focus on this technology, the procurement arrangements for FPUP would be designed to permit other technologies to be utilized as they develop (see Section F.6). These would include the use of other materials such as cadmium sulfide or gallium arsenide. Also, concentrating systems might be utilized for some applications (see Section F.5).

The following pages discuss each aspect of array manufacture in some depth. There appear to be no insurmountable problems to achieving FPUP projected production and price goals if an integrative approach to the procurement is taken.

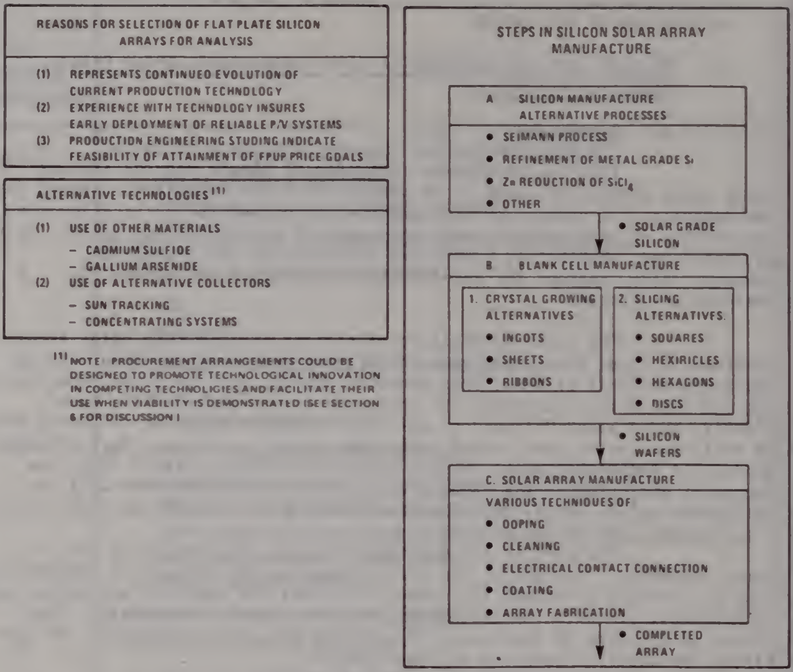

REASONS FOR SELECTION OF FLAT PLATE SILICON ARRAYS FOR ANALYSIS
(1) REPRESENTS CONTINUED EVOLUTION OF CURRENT PRODUCTION TECHNOLOGY
(2) EXPERIENCE WITH TECHNOLOGY INSURES EARLY DEPLOYMENT OF RELIABLE P/V SYSTEMS
(3) PRODUCTION ENGINEERING STUDING INDICATE FEASIBILITY OF ATTAINMENT OF FPUP PRICE GOALS
ALTERNATIVE TECHNOLOGIES (1)
(1) USE OF OTHER MATERIALS
– CADMIUM SULFIDE
– GALLIUM ARSENIDE
(2) USE OF ALTERNATIVE COLLECTORS
– SUN TRACKING
– CONCENTRATING SYSTEMS
(1) NOTE PROCUREMENT ARRANGEMENTS COULD BE DESIGNED TO PROMOTE TECHNOLOGICAL INNOVATION IN COMPETING TECHNOLIGIES AND FACILITATE THEIR USE WHEN VIABILITY IS DEMONSTRATED (SEE SECTION 6 FOR DISCUSSION)
STEPS IN SILICON SOLAR ARRAY MANUFACTURE
A SILICON MANUFACTURE ALTERNATIVE PROCESSES
• SEIMANN PROCESS
• REFINEMENT OF METAL GRADE Si
• Zn REDUCTION OF SiCl4
• OTHER
• SOLAR GRADE SILICON
B BLANK CELL MANUFACTURE
1. CRYSTAL GROWING ALTERNATIVES
• INGOTS
• SHEETS
• RIBBONS
2. SLICING ALTERNATIVES
• SQUARES
• HEXIRICLES
• HEXAGONS
• DISCS
• SILICON WAFERS
C. SOLAR ARRAY MANUFACTURE
VARIOUS TECHNIQUES OF
• DOPING
• CLEANING
• ELECTRICAL CONTACT CONNECTION
• COATING
• ARRAY FABRICATION
• COMPLETED ARRAY

Exhibit 10. Steps in Silicon Solar Array Manufacture and Reason for Selection of Flat Plate Silicon Arrays for Analysis

b. The Manufacture of Silicon

U.S. silicon producers can meet the demand for silicon which the FPUP purchase will require by using the Seimann Process. This is a process which is energy intensive and therefore costly. Currently, production costs are $40-$45/kg, and prices are about $60/kg.[3] FPUP price assumptions through 1980 are relatively insensitive to silicon prices. Price goals for 1981 to 1983 are increasingly sensitive to silicon prices.

There are two strategies for reducing raw material costs. The first is to use less silicon in cell manufacture. Exhibit 11 shows three industry estimates of silicon requirements for 152 MWp of solar arrays. By improving the efficiency in use of silicon in solar cell production, the effective cost of silicon can be reduced by a factor of four even if unit prices remain constant (i.e., use thinner cells and/or reduce materials waste.)

The second strategy is to develop new methods of silicon production. Semiconductor grade silicon which is produced by the Seimann Process is pure to one part per billion. For solar cells, less pure silicon is sufficient. The lowest price for which semiconductor grade silicon can likely be obtained using current processes is $30-$40/kg.[4] This price reduction follows from savings generated by large orders and by minor improvements in efficiency.

Several new technologies are on the horizon which will substantially lower the price of silicon. The Battelle Memorial Institute is building a pilot plant to produce 25 tons of solar grade silicon by zinc reduction of silicon tetrachloride. When geared to 1000 tons annual production, the process should yield solar grade silicon at $10/Kg. Dow Corning has tested a process for refining metallurgical grade silicon as have J. C. Schumaker and Solarex. Any of these or other competing systems can produce solar grade silicon for approximately $10/kg or less. Some of these processes could be on line by the program start date.

A FPUP market for solar cells and the existence of a number of competing processes will assure the eventual development of these processes for low cost silicon. Federal action may be required, however, to assure early availability of low cost silicon to meet FPUP purchase requirements. Dr. Leon Crossman of Dow Corning states that if a firm commitment was made now to invest in a pilot plant to produce as much as 500 tons/year of low cost, solar grade silicon, then such a plant could be on line by 1983. The Federal Government can develop a strategy to encourage such investment.

There are *several* options available to stimulate the development of new silicon processes. The Federal Government could underwrite the development of demonstration pilot plants for new techniques. Alternatively, the government could lend investment capital to would-be, low cost silicon producers with the interest rate tied to the price of silicon. Finally, increased funding and emphasis can be given to current and ongoing ERDA/JPL low cost silicon Solar Array projects. These and other alternative strategies could be pursued concurrently.

DOD PURCHASE SILICON REQUIREMENTS (METRIC TONS)

YEAR	1979	1980	1981	1982	1983	TOTALS
TEXAS INSTRUMENTS'* ESTIMATES	40	120	230	290	205	885
SPECTROLAB ESTIMATES**	81	230	461	580	406	1758
DOW CORNING*** ESTIMATES	140	400	800	1000	700	3040

*VERY THIN CELL 0.05 mm **THIN CELL 0.15 mm ***LARGE CELLS

SILICON PRICE SENSITIVITY (1)

COST OF RAW SILICON	$65/KG	$40	$30	$10
RAW MATERIAL COST/WATT (THIN)	$0.75/WATT	$0.47	$0.35	$0.12
RM COST/WATT (VERY THIN)	$0.25/WATT	$0.16	$0.12	$0.04

SILICON PRICES

	CURRENT PRICE	OLD TECHNOLOGY PRICE	NEW TECH PRICE
SEMICONDUCTOR GRADE	$60-$70/KG	$30-$40/KG	$10-$30/KG
SOLAR GRADE	$30-$40/KG	NOT AVAILABLE	$6-$12/KG

SOURCE: INDUSTRY ESTIMATES AND ERDA/JPL STUDIES

PROJECTED COST FOR PHOTOVOLTAIC ARRAYS (2)
(SILICON CONTRIBUTION)

	1977	YEAR OF 1ST PURCHASE	YEAR OF LAST DELIVERY
COST OF SILICON	$0.75/WATT	$0.59-$0.71/WATT	$0.035-$0.14

(1) COST REPRESENTS ONLY COST OF SILICON USED IN PRODUCING WAFERS.

(2) ESTIMATED COST OF PRODUCTION IN 1975 CONSTANT DOLLARS.

Exhibit 11. Silicon Prices and Requirements,
and Raw Materials Costs

The production of silicon currently contributes the smallest cost component of solar array (slicing and array fabrication being the other two components). However, cost reductions in this area may be most difficult to achieve. By encouraging the development of efficient uses of current process silicon and by stimulating the rapid development of new, energy-conserving processes of silicon manufacture, the FPUP purchase of solar arrays can stimulate the rapid development of low cost silicon production for technology. In order to ensure the availability of low cost silicon in the early 1980's (when it is needed to meet program price goals), immediate efforts are required, e.g., support development of pilot production plants, support development of alternative processes, etc.

c. The Manufacture of Silicon Wafers

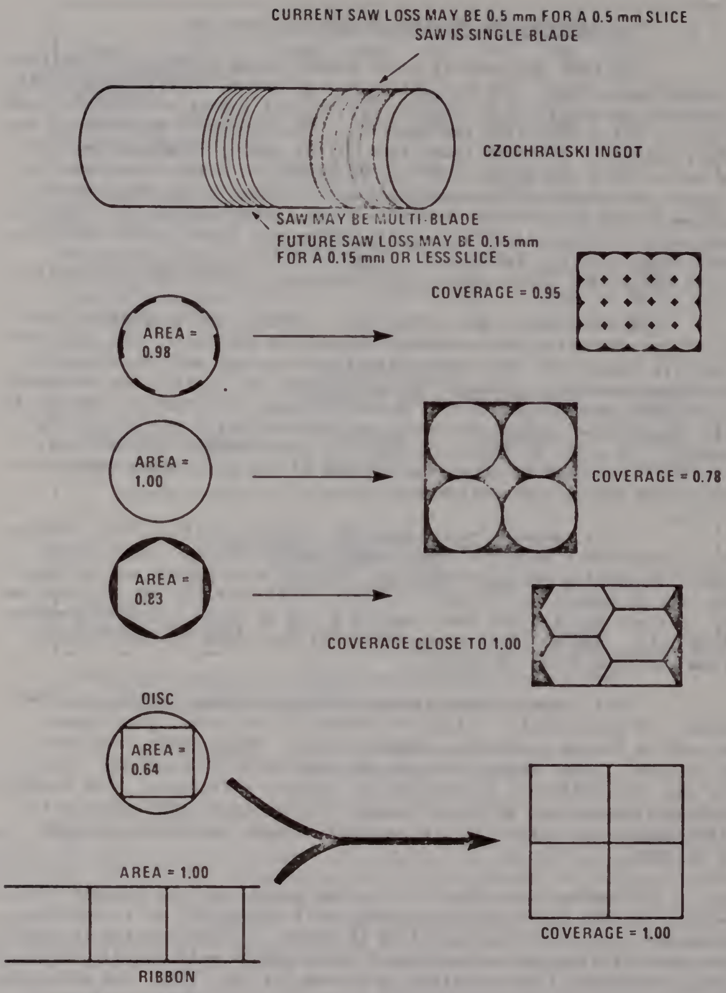
The FPUP purchase of solar arrays would stimulate lower cost silicon wafer production. The current method of making wafers (also called slices, blanks, or discs) is to produce cylindrical ingots of single-crystal silicon out of polycrystalline raw material. The ingots -- produced by the Czochralski method -- are then sawed into slices, using single blade saws. They may be cut to a new shape, and must be etched to a smooth surface to remove random saw marks. If semicrystaline silicon is used, then square cells may be sliced from "brick shaped" ingots. Other methods of producing cells are under consideration, especially ribbon and sheet growth processes to replace ingot growth. Exhibit 12 illustrates alternative shapes of wafers, and summarizes likely wafer cost estimates in 1975 constant dollars.

Ribbon, sheet and similar new methods seek to shape a thin film of silicon directly, thus avoiding sawing and saw loss. The prospects are attractive because of the simplicity of the concept and the potential savings of raw material. Although basic research and testing has uncovered several promising methods of thin film manufacture, the state-of-the-art is such that large scale production cannot be expected until the end of the DoD purchase. In order to encourage parallel development, Federal legislation could be designed to encourage the use of new production methods as they are proved and become available.

It is assumed in the analysis that the initial FPUP purchase will be of Czochralski method slices. Improvements in cell manufacture will lower the total price by automation, by mass production, and by more efficient use of expensive silicon. Exhibit 12 illustrates how savings can be made. Current multi-blade saws require a 1.0 mm thick slice to produce one 0.6 mm cell. New multiple blade saws will cut three or four 0.15 mm cells from the same 1.0mm of ingot.[5]

Cell geometry also plays a role in silicon losses in wafer production. If the circular slices are packed in an array, gaps appear. The gaps can be closed by cutting hexagons out of the circles, but then silicon is lost. Other geometries provide intermediate solutions. Competitors can take different strategies for maximum efficiency. The development of thin film methods or "brick shaped" semicrystal line ingots will also allow the use of efficient cell geometries such as squares without wasting silicon.

Manufacturers of crystal growers and saws are certain that they can provide the basic machinery which cell production will require. Lead times are expected to be only 3 to 18 months.[6] The industry is confident that both pricing and technological improvements will rapidly result from array purchases of the magnitude proposed for the FPUP. The universal prediction is that such a purchase will stimulate the industry without overtaxing its capacity for growth. Among the expected improvements are automation of production lines, improved crystal growers, new multi-blade saws, and new geometry for solar cells.



PROJECTED COST FOR SILICON WAFERS (1975 CONSTANT $) (1)

	SILICON WAFER COST ($/Wp)		
	1977	1979	1983
DISCS	$3 (2)	0.68 (3) – 1.80 (2)	0.11-18 (4)
RIBBON	--	TBD	0.11-0.18

(1) PRICES REDUCED TO COST BY DIVIDING BY 1.2; EARLY 1977 COSTS CONVERTED TO 1975 CONSTANT DOLLARS BY DIVIDING BY 1.1 TO ACCOUNT FOR INFLATION

(2) MONSANTO

(3) SOLAREX

(4) TEXAS INSTRUMENT

Exhibit 12. Current Silicon Solar Cell Configurations and Sources of Materials Loss

d. The Manufacture of Solar Arrays

Studies of silicon P/V array production processes indicate that the FPUP array price assumptions can be achieved. Current manufacture is labor intensive, small volume, and hand crafted. The principle elements of the process: doping, contact printing, coating, array laydown and connection, lend themselves to mass production processes. Individual components of these production processes are expected to be partially modular. Thus, as technological improvements and new methods are achieved in any one area, that component of the assembly line can be replaced and the end-cost correspondingly reduced.

Current array manufacturers as well as potential entrants to the industry agree that a DoD phased purchase of 152 megawatts is sufficient to stimulate automation, new efficiencies, and new processes in array manufacture without overtaxing their capacity to expand production. Industry and laboratory studies indicate a possible reduction to less than five per cent of current costs.

Exhibit 13 illustrates the predicted and potential costs of each major component of the manufacturing process. *All costs have been deflated to 1975 constant dollars.* Prices have been reduced to cost by judgmentally removing profits, interest on debt, and taxes. The row labeled "Total Price" in Exhibit 13 was derived by marking up the estimated cost by 20 percent to allow for a return on invested capital.

The cost of silicon can be expressed as a portion of the final array in terms of dollars per watt of final cost. Currently, the production cost of silicon is about $.75/watt. Volume orders and less waste of silicon in cell production could reduce that cost by 25 to 40 percent. Once solar grade silicon is available in quantity or very thin cells are being efficiently made, silicon cost will account for only $0.04 to $0.14/watt.

Silicon wafers currently add a cost of $3.00/watt to the array cost. One manufacturer could immediately reduce cost and hence prices on volume orders by a third. A 1976 Spectrolab study determined cost could be reduced to $0.68 with an 18 month lead time.[7] A 1976 Texas Instruments' study predicted ultimate costs of $0.18/watt.[8]

Finally, current cost of array manufacture is estimated to be $5.30 to $8.30/watt. Spectrolab and RCA studies indicate short lead time costs of $0.82 to $1.45/watt. RCA estimates that within eight years, costs as low as $0.24 can be achieved.[9] Total solar array costs can be easily derived by adding the three step costs together.

The availability of low cost silicon is a key element in reaching the 1983 price projections. Early array price goals are not sensitive to the cost of silicon. However, the lowest 1983 prices desired for FPUP purchases are sensitive to silicon prices. Therefore, some means of stimulating investment in low cost, solar grade silicon plants should be sought.

PROJECTED COSTS FOR PHOTOVOLTAIC ARRAYS
(ALL COSTS ARE IN 1975 CONSTANT DOLLARS)

	EARLY 1977 (\$/Wp)	1979 (\$/Wp)	1983 (\$/Wp)
COST OF SILICON	.75	.59 - .71	.035 - .14
COST OF SLICES (-RM)	3.00	.68 - 1.80	.11 - .18
COST OF ARRAY (-SLICES)	5.30 - 8.30	.82 - 1.45 (2)	.24 (3)
TOTAL COST	9.05 - 12.05	2.09 - 3.96	.39 - .56
TOTAL PRICE (1)	10.90 - 14.50	2.50 - 4.75	.47 - .67
ANALYSIS PRICE ASSUMPTIONS	▨	3.50	.75

(1) PRICE WOULD INCLUDE COST PLUS A MARK UP TO COVER PROFITS, TAXES ON PROFITS, AND INTEREST ON DEBT. A 20% MARK UP WAS INCLUDED HERE; ACTUAL VALUES WOU VARY FROM COMPANY TO COMPANY.

(2) SPECTROLAB COST ASSUMES 3.5 MWp PLANT , RCA CURRENT TECHNOLOGY 50 MWp PLA

(3) RCA STUDY ASSUMES ADVANCED TECHNOLOGY 50 MWp PLANT; COST WAS DEFLATED BY 10% TO CONVERT TO 1975 DOLLARS

PROBLEMS TO INDUSTRIAL EXPANSION AND PRICE REDUCTION

1. LOW COST SILICON
   - REQUIRES IMMEDIATE INVESTMENT TO BECOME AVAILABLE WHEN NEEDED
   - INVOLVES SOME FINANCIAL RISK
   - INCREASES ASSURANCE OF ACHIEVING FUTURE PRICE GOALS
   - IMPORTANCE DIMINISHES IF LESS MATERIAL REQUIRED PER Wp OF ARRAY CAPACITY (I.E., RESULT OF HIGHER CELL EFFICIENCY OR GREATER PRODUCTION EFFICIENCY)

2. INVESTMENT CAPITAL RISK FACTORS
   - RAPID OBSOLESCENCE OF PRODUCTION EQUIPMENT (1)
   - UNCERTAINTY IN MAGNITUDE AND DURATION OF BUY (2)
   - RAPID OBSOLESCENCE OF ARRAY TECHNOLOGY (3)
   - ASSURANCE OF SUSTAINING MARKET (4)
   - POTENTIAL NEW PROCESSES COULD BYPASS NEED TO USE LARGE-SCALE SILICON MANUFACTURERS

(1) SEE SECTION F.6 FOR DISCUSSION OF USE OF GFE

(2) SEE SECTION F.3 FOR DISCUSSION OF BUSINESS VOLUME REQUIREMENTS

(3) SEE SECTION F.5 FOR DISCUSSION OF USES OF FLAT PLATE COLLECTORS

(4) SEE SECTION F.4 FOR DISCUSSION OF SUSTAINING MARKETS

Exhibit 13. Summary of Projected Array Costs and Problem Areas

2. Price Estimates and Volume Sales

Independent statistical predictors indicate that FPUP solar array prices can be attained at or ahead of schedule. Experience curves are a powerful tool for predicting costs and prices for technologically new products.[10] Experience theory states that every time cumulative production volume doubles, production costs will decline by a fixed percentage. The effects of improved products, production processes, and economies of scale are accounted for in these cost reductions.

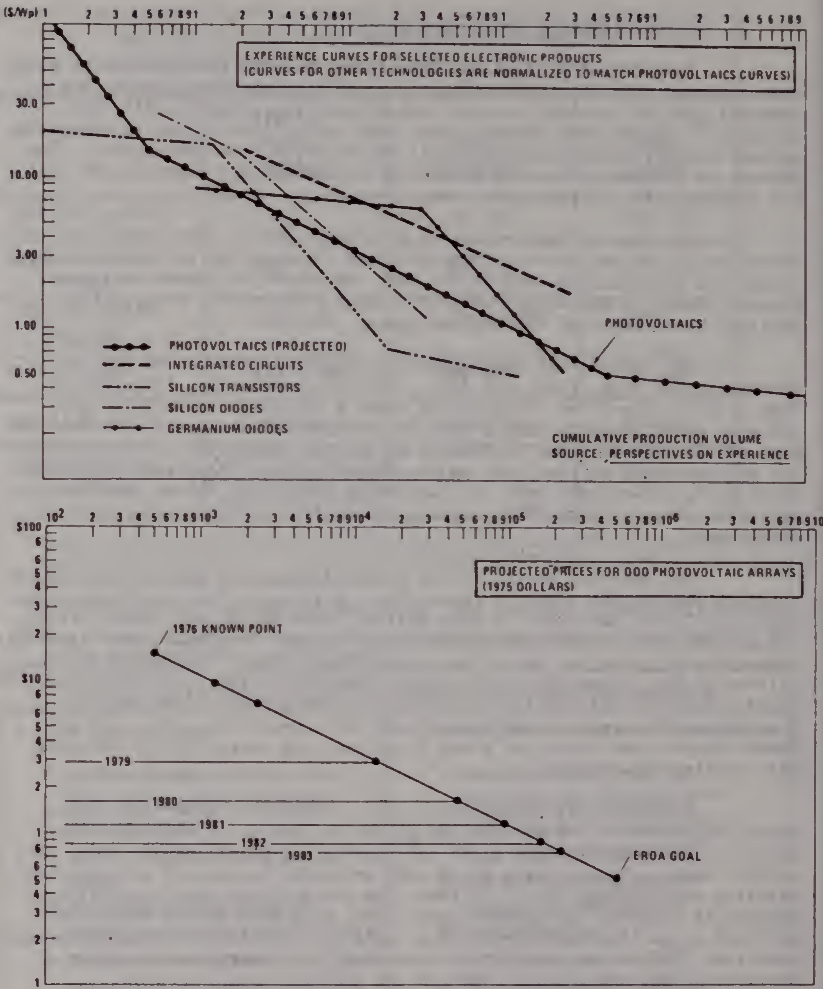
The rate of decline varies by product and is seen graphically as the slope of the projection. Many American corporations in high technology fields use experience curves as the best indicators of future costs and prices. Such a graph can be used to project photovoltaic array price declines as a result of the FPUP purchase.

The terrestrial photovoltaics industry is too new to plot an accurate curve from historical data. The best prediction, therefore, is from similar industries. Exhibit 14 shows a projected curve for photovoltaics based on known 1976 prices and cumulative sales, and with the ERDA goal of 500 megawatts and $0.50/watt as the two known points. The curves are not dependent on time, but on production volume. Predicted production costs apply at whatever date the cumulative production volume goal is achieved. Thus a large FPUP purchase should lead to rapid reductions in array cost.

The question which must be answered to assure the accuracy of the curve is whether the slope is reasonable. A steeper slope would mean more rapid unit price declines. A more shallow slope would mean higher prices. The exhibit shows known experience curves for other semiconductor/electronics industries projected on top of the photovoltaic graph. Silicon transistors, silicon diodes, germanium diodes, and integrated circuits all have experienced production cost declines similar to those projected for photovoltaics. The ERDA goals seem reasonable based upon the comparison, since all of these products had slopes of about 70 percent (30 percent price decrease with doubled experience).

Assuming that photovoltaics costs follow the experience curve shown in Exhibit 14, we can predict prices by reading in expected sales volume at the bottom of the graph and reading out prices on the left. The exhibit shows a low estimate based upon projected commercial purchases for existing applications only. In fact, the DoD purchase should stimulate commercial sales in new market areas. Thus projected prices should be achieved at earlier dates than those indicated. The market size and prices resulting from the buy are "to be determined" in later, more detailed analyses. They are labeled "TBD" in the exhibit.

The application of experience curve theory to photovoltaics independently confirms the projections of industry price estimates described in the preceding section.



Year End	1977	1978	1979	1980	1981	1982	1983
Proposed DOD Purchase (MWp)	0	0	7	20	40	50	35
Low Estimate of Commercial Buy (MWp) (Without Buy)	0.72	1.4	4.2	9	12.4	20	24.5
Cumulative* Subtotal	1.22	2.6	13.8	43	95	165	223
Resulting Projected Price (1975 $'s)	–	–	$2.90	$1.60	$1.15	$0.85	$0.75
Large Commercial Market Induced By Buy	–	–	TBD	TBD	TBD	TBD	TBD
Total	TBD	TBD	TBD	TBD	TBD	TBD	TBD
Projected Price	–	–	–	TBD	TBD	TBD	TBD

*CUMULATIVE SUBTOTAL USED TO DEVELOP ESTIMATED YEAR END PRICES ON EXPERIENCE CURVE IN CENTER

Exhibit 14. Predicted Photovoltaic Prices Based on Experience Curves

3. Business Volume Requirements

The proposed FPUP purchase option would be sufficient to stimulate economies of mass production while attracting and supporting enough competitors to maximize the introduction of new technologies in manufacturing. Investment analysts estimate that a mature photovoltaics industry should promise an eventual $250 million or more in annual sales to attract large bank and equity investment, and the industry should exhibit a 25 percent annual growth rate in dollar sales.[11] The proposed Federal photovoltaics utilization program will, in conjunction with presently expected minimum commercial sales, provide a large initial dollar growth rate over the first three years of the program. Exhibit 15 summarizes the business volume likely to be generated by FPUP. It also identifies additional sales required to produce continued business volume growth during 1982 and 1983.

In particular, the FPUP purchase option provides for a strong, multi-year Federal commitment - a first buy of 32 MWp with deliveries phased over 3 years, and a 152 MWp five-year commitment. This stimulus will initiate a drive toward industrial maturity which might otherwise be long delayed. These delays could result from the inability of the industry to attract sufficient venture capital to realize economies of mass production and resulting cost reductions. The proposed FPUP purchase will attract investment capital by offering private investors the security of an assured product market that a five-year Federal guaranteed buy can provide.

To maintain a 25 percent dollar volume increase while simultaneously lowering prices, actual unit sales must increase at a rate greater than dollar volume. These sales must almost double each year through 1983. The DoD purchase and current minimum expected civilian sales will be sufficient to maintain dollar growth at well over 25 percent during the first three years of the program. However, in the fourth year, lower prices, product acceptance and new product uses (which are appearing every day) must generate $35 million in new sales or 28 MWp in new demand at the array prices assumed for the FPUP buys. In the fifth year, an additional $110 million worth of P/V arrays must be sold -- 146 MWp at the assumed 1983 unit price of $.75/Wp. These sales include any Federal purchases outside the FPUP program. Analyses indicate that the potential market for 1982-83 is several times these figures.[12]

Industry and financial experts agree that the proposed total FPUP expenditure of $240 million for array production would occur at a strategic time in the development of a photovoltaic industry.[13] Also, it would be sufficient to attract bank and equity investment for the approximately $150 million required to expand industry capacity. This expanded capacity would be sufficient to meet 1983 business volume requirements. Large corporations should be able to meet investment capital requirements from internally generated funding. However, smaller corporations would require outside sources of funds. The Federal purchase should guarantee a certain percentage of sales to small corporations, thus making them able to attract the venture capital necessary to rapidly expand their operations.

		1978	1979	1980	1981	1982	1983	TOTAL
WEIGHTED AVG PRICE		$7.50	$3.50	$2.50	$1.90	$1.25	$0.75(3)	
PROPOSED FPUP ARRAY PURCHASE	MWp	–	7	20	40	50	35	152
	$(1)	–	25	50	76	63	26	$240
MINIMUM NON FPUP MARKET	MWp	1.4	4	9	12	20	25	70
	$	9	15	23	22	25	18	$103
ADDITIONAL SALES REQUIREMENTS (2)	MWp	–	–	–	–	28	146	174
	$	–	–	–	–	35	110	$145
TOTAL SALES	MWp	1.4	11	29	52	98	206	396
	$	9	40	73	98	123	154	$488
GROWTH RATE,	MWp	–	690%	163%	79%	88%	110%	
	$	–	344%	83%	34%	26%	25%	

(1) MILLIONS OF 1975 CONSTANT DOLLARS

(2) ADDITIONAL SALES REQUIRED TO PRODUCE A 25%/YEAR INCREASE IN BUSINESS VOLUME

(3) ADDITIONAL SALES VOLUME SHOULD INDUCE MORE RAPID UNIT PRICE DECLINES. THUS ACTUAL PRODUCTION VOLUME REQUIREMENTS MAY BE LARGER THAN SHOWN FOR 1982 AND 83 IF RAPID BUSINESS VOLUME BUILD UP IS TO BE MAINTAINED

Exhibit 15. Projected Unit and Dollar Volume for Photovoltaic Arrays

Because a smaller volume purchase may not promote a sufficient investment in large production lines to assure both mass production and competition, there may be a risk that private capital sufficient to assure the growth of the industry would not be forthcoming. There is some threshhold purchase size of undetermined quantity and duration which will assure the industry's "takeoff." The 152 MWp option is sufficient to lower prices and maintain competition. *The lower limit on buy size has not been determined.*

The market generated by the proposed FPUP should allow three to five major manufacturers of photovoltaic arrays and wafers to develop. The larger companies may choose to manufacture their own silicon. At present, one or two silicon manufacturers are expected to provide most of the initial program silicon requirements. However, new technologies may lead P/V manufacturers to process their own silicon.

Several features that would address business volume requirements might be incorporated into enabling legislation: provision could be made for large, multi-year purchases to encourage expansion of production and economies of scale. A fraction of the buy might be reserved for small manufacturers, perhaps for specific and special end uses. No manufacturer should be allowed to sell only to the government. Purchases or prices should in some way be contingent upon active development of a commercial market by each participant.

4. Potential Sustaining Markets

a. DoD Markets for Low Cost Photovoltaic Power Systems

DoD markets having a cumulative size of 1000's of MWp could sustain industry growth at the conclusion of the Program. The size of these markets would be dependent upon the assumed escalation rate in the cost of conventional energy, the days per year of operation for the generators, and potential innovations in energy storage technology and other factors (refer to Exhibit 7). These results are summarized in Exhibit 16.

Total market size estimates are based on 8 hours per day of operation. Market size would scale almost linearly if actual daily operating time differed from this figure. The equipment cost of the generator has been included in the calculations, and the effects of lower energy storage costs and system costs have been explored. Thus, breakeven prices are higher than the prices reported in Section C.2.

Assuming 8 hours per day of operation for 250 days per year, photovoltaic power systems should provide cost effective replacements for diesel and gasoline engine-generator sets rated at 15 KWe or less. These results hold with or without an assumed escalation rate of two percent per year in the real cost of conventional energy. Breakeven array prices of over $1.00/Wp hold in either instance. These breakeven figures would increase if system costs below $1.00/Wp were attained, or they would decrease if the equipment had to meet particularly stringent military specifications. The latter requirement would be application specific.

These results are highly sensitive to the number of days per year of equipment operation. As shown in Exhibit 16, the array breakeven price declines by 50 percent or more for equipment operating 125 days per year rather than 250. It is assumed that the costs associated with photovoltaic power systems remain constant in this situation. However, annual operating and maintenance expenses for the conventional power system would be halved.

Innovations in energy storage technology would begin to open substitution markets for replacement of 30 and 60 KWe generators. For example, iron redox batteries costing $10/KWHR could open these markets. Under this battery price assumption, breakeven array prices for photovoltaic power systems are in the $.65-$.86/Wp range for a system designed to replace a 60 KWe generator. These prices apply in 1977, and they are given in 1975 constant dollars. These markets would develop more rapidly if system prices declined below $1/Wp in that time period.

Other markets not shown in the exhibit include power supplies for remote test site instrumentation, remote islands, remote radar sites, and other large scale remote applications. These and other promising applications were described in a "DoD Photovoltaic Energy Conversion Systems Market Inventory and Analysis."

	BREAKEVEN PHOTOVOLTAIC ARRAY PRICES								
	Zero Escalation Rate in Real Cost of Conv. Energy			0.02 Escalation Rate in Real Cost of Conv. Energy			Inventory	Array Size**	Cum. Market
Days/Year of Operation Gen. Rating	250	125	250*	250	125	250*	(1000's)	(KW_p)	(MW_p)
1.5 KWe GED***	11.47	5.72	12.60	14.15	7.16	15.27	70	1.9	133
3.0 KWe GED	5.96	2.65	7.08	7.49	3.48	8.62	57	3.8	217
5.0 KWe GED	4.29	1.69	5.41	5.49	2.33	6.61	38	6.3	228
10.0 KWe GED	2.20	0.52	3.33	2.97	0.93	4.10	49	12.6	588
5 KWe DED	2.71	0.99	3.83	3.52	1.44	4.65	2	6.3	13
10 KWe DED***	1.09	0.03	2.22	1.60	0.30	2.72	4.2	12.6	53
15 KWe DED	1.02	0.02	2.15	1.51	0.29	2.64	5.95	18.9	112
30 KWe DED	0.05	−0.59	1.18	0.36	−0.42	1.48	9.2	38	350
60 KWe DED	−0.48	−0.91	0.65	−0.27	−0.80	0.86	13.6	75	1020
TOTAL									2700

* Assuming $10/KWHR storage costs and $300/KWp system costs.
Other columns assume $50/KWHR storage cost and $1000/KWp system cost.
Fuel transportation cost is not included (i.e., remote applications would have higher breakeven price).

** For 8 hours of power per day

*** GED — Gasoline engine driven generators
DED — Deisel engine driven generators

NOTE: Areas not shaded offer potential markets during program.

Exhibit 16. Additional Market Potential Within DoD -- Sensitivity of Breakeven Array Prices to Escalation Rates, Days Per Year of Operation, and Energy Storage Costs

b. Potential Commercial Markets

There are numerous applications for P/V power systems in the private sector which have parallel applications in the Federal Government. Exhibit 17 enumerates some applications that, at present, appear to offer the most significant markets. The Federal Government applications will contribute to the development of a commercial market that could provide competitive P/V power systems vis-a-vis present power systems by reducing or eliminating existing economic or technical barriers. Also, applications engineering funding for FPUP applications may result in products which can be readily transferred to the private sector.

Area lighting, such as street lighting, construction lighting, or parking lot lighting, can be segmented into moderately small units. It offers an attractive parallel to military base lighting requirements. Units could be conveniently grouped into 10 KWp or smaller size packages for lighting up to a 500 X 1000 foot parking lot based on the stated energy requirements, or individual units could be developed for each light. The most attractive size must be determined. Those factors affecting choice of units, as noted above, will determine whether a totally distributed P/V system, a totally centralized system, or something intermediate is selected.

Numerous areas such as airport runways, buildings, power lines, bridges, etc., use warning marker lights. Power usage by such devices is low for individual units, but many markers on a large number of structures could provide a moderately large market. The Department of Transportation offers both FPUP and sustaining market applications in this area. These applications also have transfer potential to the private sector. Also, early, cost effective military parallels are easily seen re: marker lighting for fences, buildings, towers, and runways in which the DoD has performed engineering/production capability development.

Installation of cathodic protection devices for pipelines, wells, and tanks at a number of U.S. Air Force bases will provide corrosion protection. Similar units are being installed in commercial systems. P/V systems offer attractive power sources when such use occurs at a remote site.

Another potential application that appears to have merit is the use of P/V energy storage systems to operate power tools of various kinds in machine shops or in mobile shops. Almost any size machine shop could be powered in this manner. Pumps that can be utilized in agriculture or other areas to pump water or fuel would be useful, and the potential market is very large.

The FPUP should cause array prices to decline to the point where photovoltaics are on the threshold of penetrating certain residential markets (e.g., peak load shaving).[15] Continued escalation in the cost of fuel and generation capacity, changes in peak load and declining block rate pricing policy, regional variations in insolation, and the share of the load provided by solar power will influence the time when cost effectiveness is achieved for different segments of the residential market.

DESCRIPTOR / POTENTIAL NON DOD APPLICATION	POTENTIAL USERS		PRESENT POWER SOURCE	CONVENTIONAL SYSTEM ENERGY REQUIREMENTS AND COST ASSUMPTIONS	ASSUMED ARRAY SIZE REQUIRED	TOTAL UNITS IN PLACE (ALL POWER SOURCES)	CUMULATIVE MARKET (MW$_p$)	ANNUAL SALES (UNITS)[3]	MAXIMUM ANNUAL MARKET POTENTIAL (MWp)
	EXAMPLE FPUP PARTICIPANTS	OTHER SUSTAINING							
• AREA LIGHTING – STREET LIGHTING – PARKING LOT LIGHTING – HIGHWAY LIGHTING	• FHWA (DOT) • DOD	• FHWA • STATE HGWY DEPTS. • COMMERCIAL ESTABLISHMENTS, ETC	• COMMERCIAL POWER LINES	150 1000 WATTS/LIGHT 150 200 FT APART $6-10/FT – UNDERGROUND CABLES	≤ 10 KWp 1.2 KWp	60 80 MILLION	81 108 000 MWp	5,000 000	3,000
• MARKING & WARNING DEVICES – BLINKING WARNING LIGHTS – EMERGENCY LIGHTING	• FAA (DOT) • COAST GUARD (DOT) • NHTSA (DOT)	• STATE AND LOCAL GOVTS	• ENGINE GENERATORS • BATTERY • COMMERCIAL POWER LINES	1 5 KW GEO $1 200 2500* $50 125/ KWHR – LEAD ACID	~1 KW WATTS/ UNIT + POWER LOSS IN STEP DOWN UNIT	120,000	15 120	15,000	1 215
• CATHODIC PROTECTION – PIPELINES – WELL CASINGS – UNDERGROUND STORAGE	• DOD	• OIL COS • INDUSTRY	• GALVANIC ANODE • ENGINE GENERATOR	$6 10/FT (UNDERGROUND) $5 9/FT (OVERHEAD) $12 50 37 50/1000 FT^3/YR $2 5000 – 0 15 KW GEO*	50 000 W$_p$	PIPELINES 2,885 000 UNITS WELLS 510,000 TANKS 100 000	100	N/A	N/A
• POWER FOR ELECTRICALLY DRIVEN MOTORS (1 5 HP) – SHOP EQUIPMENT – REPAIR TOOLS – HAND TOOLS – GENERAL PURPOSE EQUIPMENT	• DOD	• CONSTRUCTION FIRMS • INDUSTRY • CONSUMERS	• COMMERCIAL POWER LINES • BATTERY • PORTABLE ENGINE GENERATOR	$50 125/KWHR – LEAD ACID $1700-4500* FOR 1 5-10KW GEO OR DEO	≤1 KWp/TOOL ≤10 KWp FOR A SMALL SHOP	15 000 000	15	2,300 000	2,300
• POWER FOR REMOTE AREAS – FIELD INSTALLATIONS/ FACILITIES – REMOTE BASES/PLANTS/ STATIONS AND VILLAGES	• DOD • FOREST SERVICE	• REMOTE ORE PROCESSING • REMOTE RESIDENCES	• ENGINE GENERATOR • COMMERCIAL POWER LINES • COMMERCIAL POWER LINES	$7 500 25 000[1] 5 200 KW GEO OR DEO $5 9/FT – $ 00/FT OVER POWER LINES	≤10 KWp/SITE	TBD[2]	TBD	TBD	TBD
• ENGINE GENERATOR MARKET – GASOLINE (GEO) (50% PRIMARY POWER) – DIESEL (DEO) (20% PRIMARY POWER)	• DOD	• CONSTRUCTION • RECREATIONAL VEHICLES • AGRICULTURE	• ENGINE GENERATORS	0-5KW – $1 000 $2,000 0 15 KW – $2 500 7,500 0-15KW – $1,000 7,500 15-100KW – $7 500 14 000 100 500KW – $14 000	5 X GENERATOR SIZE	0-5KW – 975 000 5 15KW – 150,000 0 15KW – 64,000 15-100KW 60,000 100 500KW 84 500	8,200 50 000 (5,000MW$_p$)[4]	(1975) 0 5KW – 200,000 0-15 KW – 30,000 0 15KW – 8 500 15 100KW – 7,000 100 500KW – 6 300	1700 (170) 4,400 (440)
• SMALL PUMPS (1 5 HP) – FUEL PUMPING – WATER PUMPING – WATER PUMPING (U S & FOREIGN)	• DOD • USAID • DOC	• U.S. AGRICULTURAL INTERESTS • DEVELOPING COUNTRIES	• COMMERCIAL AC (60% (E)) • ENGINE GENERATORS (40% (E))	$5 10/FT (UNDERGROUND) $8 9/FT (OVERHEAD) 0 5 KW – $1,000 – $2,500	2 5 KWp/PUMP	5,000,000	8,500	1,000 000	5 000
RESIDENTIAL	• DOD, HUD	• UTILITIES • CONSUMERS	• COMMERCIAL POWER	$.02 .08/KWHR	0 7 KWp	70 000,000	500 000 (CURRENT MARKET)	2,000,000	15,000
COMMUNITY/ INDUSTRY ELECTRIC POWER SUBSTATIONS	• DOD	• UTILITIES • INDUSTRY	• COMMERCIAL POWER	$.02 – .08/KWHR	TBD	TBD	TBD	TBD	TBD

[1] EQUIPMENT COST ONLY
[2] TBD - TO BE DETERMINED
[3] SOURCE U S CENSUS BUREAU

[4] WITH REPLACEMENT OF ONLY 10% OF UNITS IN PLACE SINCE MOST UNITS FOR STANDBY POWER
GEO = GASOLINE ENGINE DRIVEN GENERATOR (ACQUISITION COST IN 1975 DOLLARS)
DEO = DIESEL ENGINE DRIVEN GENERATOR (ACQUISITION COST IN 1975 DOLLARS)

Exhibit 17. Sectors for Potential Technology Transfer from DoD to Commercial Non-DoD Market

5. The Flat Plate Collector Should Play a Significant Future Role

The flat plate collector will play a major and continuing role in evolving Federal and private sector markets. Other competing technologies such as concentrating systems may prove to have advantages in certain applications. However, flat plate arrays are likely to play a key role for remote site, DoD, and residential applications among other major application areas. These markets potentially total thousands of MWp. An additional value of the program results from the funding of product development. Thus, the program will produce a variety of products engineered to use virtually any photovoltaic power system.

Concentrating systems would limit requirements for silicon solar cells or promote the use of other materials such as gallium arsenide. The concept involves the concentration of solar radiation with the use of inexpensive focal lenses onto fewer photovoltaic cells. The system may be equipped with a small tracking device which will improve energy captured by direct solar alignment. These systems reduce the quantity of photovoltaic cells required over the flat plate collectors in proportion to the concentration ratio. The efficiency of a silicon concentrator array is somewhat reduced relative to the efficiency of a flat plate array. However, the high ratio of collector aperture area to P/V array area produces a much higher energy output per unit area of cell.

Much of the industry infrastructure created through the FPUP could become obsolete if concentrating systems became the technology of choice for all major photovoltaic applications. However, an examination of the advantages and disadvantages of both technologies indicates that flat plate arrays should play a significant and continuing role in major market areas. Both systems offer advantages and disadvantages such as those identified in Exhibit 18.

Flat plate arrays have an advantage relative to concentrating systems since they can be mounted in fixed positions. On the other hand, high concentrating systems require sun tracking systems. These tracking systems increase the operating and maintenance costs. Thus, flat plate arrays mounted in fixed positions should be the technology of choice for operation in harsh or remote environments. Also, they are more easily integrated into the structure of a building. For example, flat plate arrays could be used as an integral part of the roof of a residence. This would provide a cost advantage relative to concentrating systems, since photovoltaic arrays could be used as a substitute for conventional shingles.[16]

Concentrating systems appear to offer at least a near term price advantage relative to flat plate arrays -- recent reports indicate a possible $2/Wp price for 1978 systems.[17] However, FPUP should rapidly drive the price of flat plate collectors to this level and assist in further reducing concentrating system prices. Further, industry has already collected several years of experience with flat plate collectors, while concentrating systems are still under development.

ATTRIBUTE	COLLECTORS	
	FLAT PLATE	CONCENTRATORS
1. COST OF CELL MATERIAL	• HIGHEST COST ITEM PRESENTLY	• COST REDUCED IN LINEAR PROPORTION TO CONCENTRATION RATIO
2. COST OF STRUCTURES	• FIXED POSITION STRUCTURE SIMPLEST AND LOWEST COST	• TRACKING SYSTEM WITH OPTICS INCREASES COST
3. RELIABILITY/MAINTAINABILITY/ENVIRONMENTAL EFFECTS	• SIMPLE, FIXED POSITION SHOULD GIVE HIGH RELIABILITY AND LOW OPERATION MAINTENANCE	• TRACKING SYSTEMS INCREASE MAINTENANCE REQUIREMENTS
4. APPROPRIATE APPLICATIONS	• DOD FIELD EQUIPMENT • FIELD POWER SYSTEMS • REMOTE SITES • RESIDENTIAL (E.G., AS A PART OF THE STRUCTURE)	• FIELD POWER SITES • COMMUNITY/INDUSTRIAL POWER SYSTEMS • TOTAL ENERGY SYSTEMS
5. AESTHETICS	DEPENDS ON APPLICATION AND DESIRE OF PURCHASER	

Exhibit 18. A Comparison of the Advantages and Disadvantages of Flat Plate and Concentrating Arrays

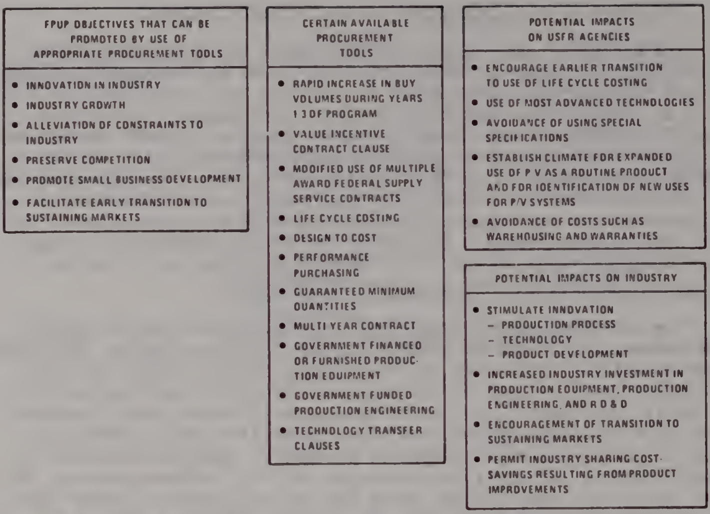
6. The Importance of Procurement/Distribution Procedures

The design of the procurement procedures for the Federal Photovoltaic Utilization Program (FPUP) is crucial to the accomplishment of the goals of the Program. Such procedures can provide one of the most powerful incentives to photovoltaic commercialization. Procurement procedures must be designed to promote certain Program goals: industry growth; innovation; alleviating constraints to development; preserving competition; promoting small business development; and facilitating early transition to sustaining markets. Accomplishment of all of these goals can be facilitated by the careful selection and combination of existing procurement mechanisms. On the other hand, poorly designed and poorly managed procurement procedures can thwart the objectives of the FPUP. Exhibit 19 lists available procurement tools that may be used to achieve FPUP goals.

The existing Federal procurement system provides the necessary framework and specific tools to promote the goals of the FPUP for both user-agency and industry. Procedures can be designed to facilitate the user-agency's selection of systems on the basis of life cycle costing, use of "off the shelf" equipment (i.e., avoid unnecessary special specifications); use of the most advanced systems; and early transition to non-FPUP buys (i.e., use of photovoltaics as a routine product). Specific mechanisms that impact industry and merit consideration for the implementation of the FPUP are: multi-year contracting; value incentive contract clauses; modified use of multiple-award Federal Supply Schedule (FSS) contracts; and use of guaranteed minimum purchase commitments, etc. A set of procurement procedures for the FPUP that is designed to accomplish Program goals will likely incorporate a *specially designed combination* of these mechanisms.

A Federal Photovoltaic Utilization Program will require multi-year contracting to achieve its goals. Multi-year contracting with incentive clauses will permit substitution of more advanced systems as they are developed and will remove barriers to industry investments that would promote growth and innovation by substituting predictable for unpredictable funding. FPUP buys can be sequenced to produce rapid increases in production/business volume over the first three years of the program. It is assumed that the Program buys provide industry with the market assurance necessary for them to invest in the production equipment, production engineering and R&D required for innovation.

New and more cost effective production processes and improvements in the technology can be expected from such R&D investments. Also, long term (multi-year) contracting better facilitates industry use of government financed or furnished production equipment (GFE) or special tooling, and of government funded production engineering, for processes and equipment subject to rapid obsolescence.



FPUP OBJECTIVES THAT CAN BE PROMOTED BY USE OF APPROPRIATE PROCUREMENT TOOLS

- INNOVATION IN INDUSTRY
- INDUSTRY GROWTH
- ALLEVIATION OF CONSTRAINTS TO INDUSTRY
- PRESERVE COMPETITION
- PROMOTE SMALL BUSINESS DEVELOPMENT
- FACILITATE EARLY TRANSITION TO SUSTAINING MARKETS

CERTAIN AVAILABLE PROCUREMENT TOOLS

- RAPID INCREASE IN BUY VOLUMES DURING YEARS 1 3 OF PROGRAM
- VALUE INCENTIVE CONTRACT CLAUSE
- MODIFIED USE OF MULTIPLE AWARD FEDERAL SUPPLY SERVICE CONTRACTS
- LIFE CYCLE COSTING
- DESIGN TO COST
- PERFORMANCE PURCHASING
- GUARANTEED MINIMUM QUANTITIES
- MULTI YEAR CONTRACT
- GOVERNMENT FINANCED OR FURNISHED PRODUCTION EQUIPMENT
- GOVERNMENT FUNDED PRODUCTION ENGINEERING
- TECHNOLOGY TRANSFER CLAUSES

POTENTIAL IMPACTS ON USER AGENCIES

- ENCOURAGE EARLIER TRANSITION TO USE OF LIFE CYCLE COSTING
- USE OF MOST ADVANCED TECHNOLOGIES
- AVOIDANCE OF USING SPECIAL SPECIFICATIONS
- ESTABLISH CLIMATE FOR EXPANDED USE OF P V AS A ROUTINE PRODUCT AND FOR IDENTIFICATION OF NEW USES FOR P/V SYSTEMS
- AVOIDANCE OF COSTS SUCH AS WAREHOUSING AND WARRANTIES

POTENTIAL IMPACTS ON INDUSTRY

- STIMULATE INNOVATION
  - PRODUCTION PROCESS
  - TECHNOLOGY
  - PRODUCT DEVELOPMENT
- INCREASED INDUSTRY INVESTMENT IN PRODUCTION EQUIPMENT, PRODUCTION ENGINEERING, AND R D & D
- ENCOURAGEMENT OF TRANSITION TO SUSTAINING MARKETS
- PERMIT INDUSTRY SHARING COST-SAVINGS RESULTING FROM PRODUCT IMPROVEMENTS

Exhibit 19. FPUP Goals Promoted By Use of Selected Available Tools, and Resulting Impacts on User Agencies and Industry

Value incentive contract clauses may be used to promote innovation and growth in the P/V industry. These clauses provide the impetus for emphasis on the enhancement of the basic functions or characteristics of a product as opposed to emphasis on those aspects of a product that are peripheral to the accomplishment of the basic purposes of the product. Carefully designed value incentive contract clauses permit a supplier to share in procurement cost-savings, and thereby share with the Government the benefits of product improvements.

If multiple-award Federal Supply Schedule (FSS) contracts are used in the FPUP, they should be used only for the purchase of P/V arrays that meet established performance criteria. The manner in which multiple-award contracts are used must be modified if they are to facilitate the achievement of FPUP goals. The advantage of multiple-award contracts is that they emphasize purchase of commercial grade equipment and allow the Federal government to purchase items "off the shelf" and thereby obtain the latest available technology. This method of purchase also avoids many costs for the Federal government, such as costs for: contracting; warehousing for large inventories; and warranties.

Purchase on the basis of *life cycle costing* and *performance criteria* are additional procurement tools. These tools are capable of providing incentives for innovation in the P/V industry. For example, performance criteria can be developed for use with multiple-award contracts. Criteria used in this way should promote both innovation and stimulate competition within the industry.

7. Effects of Requirements for Mobility on DoD Utilization of Photovoltaics

The replacement of gasoline driven engine generator sets with P/V power systems will lead to substantially reduced logistics requirements. The battery storage system for the P/V alternative has a substantial weight and volume. However, fuel requirements for the conventional generator are significantly greater. Exhibit 20 illustrates some of the volumetric tradeoffs between required battery storage volume and fuel storage volume required to supply 10 KWp over a one year period. It was assumed that each system would operate for a 10 hour day during this period.

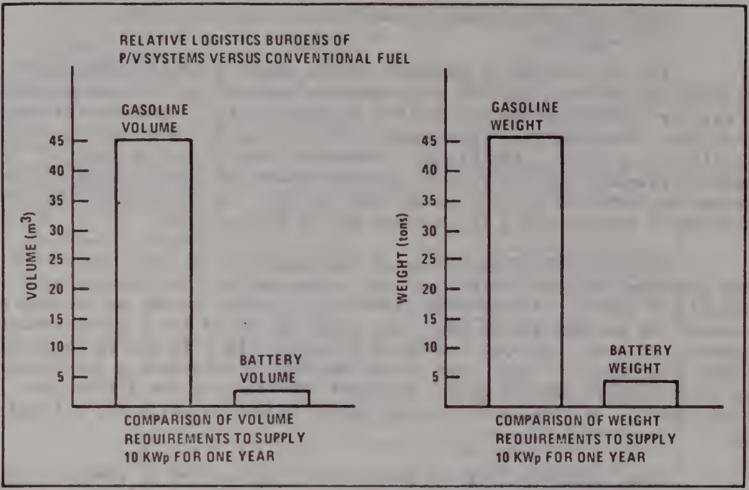
Present technology indicates that the Ni-Cd or Ag-Zn batteries would probably last six months over the charge cycles (two battery sets replaced per year). If lead-acid batteries are used, it may be necessary to double the battery volume over that shown for Ni-Cd for a given amount of power. However, with the lead-acid batteries the life can be extended to about five years. Thus, even though Exhibit 20 indicates a ten-to-one fuel-to-battery volume and weight tradeoff, the factors for a five year period could be as high as 50 through use of lead-acid units for a fixed site.

Thus, photovoltaics are particularly attractive as power sources for applications requiring limited mobility or in fixed positions. Examples include:

(1) Communications requirements utilizing less than 10 KWp, initially;
(2) Kitchen facilities and administration requirements;
(3) Maintenance functions in the general support area that could require up to 10 KWp;
(4) Power for electrically driven tools and test equipment;
(5) Remote test site instrumentation;
(6) Heliport and airfield marker lighting;
(7) Lighting sets for rear area use;
(8) Airfield control systems;
(9) Water purification sets for engineer units.

Several of these requirements, such as those listed as items (1)-(4), can be satisfied by the use of motor-generator (MG) sets driven directly by conditioned DC power from a P/V system. The largest of these applications would require in the neighborhood of 100 square meters of collector surface. Photovoltaic power systems for applications having lower power requirements such as fixed communications equipment can be incorporated in the appropriate roof structure. Other applications require conditioned DC power and this can be supplied without resorting to inversion techniques, such as those applications listed in (5) through (9) above.

None of these applications requires utilization of a mobile operating system but can be considered as "permament" installations. However, all the applications can be serviced by a mobile maintenance team with the maintenance cycle requirement being dependent upon power system accessibility.



ASSUMPTIONS FOR COMPARISONS

GENERATOR SETS (Operate 10 hrs/day).

1 pt gasoline/hr/HP rating = 500 watts/HP electric power available

∴ 10 hr/day requires 10 pts gasoline/HP rating

and in order to produce 10KWp, require 20 HP engine.

To run a 20 HP engine requires: 25 gals. gas/10 hr. day

750 gallons gasoline per month or 9000 - 10,000 gals/yr.

Thus the engine uses 40 - 50m^3/of gasoline per year.

∴ Since gasoline weighs ≈ 1 ton/m^3 → 40 - 50 tons gas/yr.

BATTERIES (Operate 10 hrs/day)

Batteries designed to meet MIL Specs.

a. Ni-Cd Batteries supply ≈ 250 watts/ft^3 @ 24 V
" " weigh ≈ 100 lb/ft^3

b. Ag-Zn Batteries supply ≈ 500 watts/ft^3 @ 24 V
" " weigh ≈ 100 lb/ft^3

c. Lead-Acid Batteries supply ≈ 175 watts/ft^3 @ 24 V
" " weigh ≈ 110 lb/ft^3

To supply 10 KWp requires 40 ft^3 Ni-Cd or 20 ft^3 Ag-Zn batteries for weight of 1-2 tons. Volume of batteries ≈ 1 m^3

The P/V collectors and generator set will probably weigh about the same (1-2 tons) as the batteries.

Exhibit 20. Comparison of Weight and Volume of Gasoline versus Batteries to Supply 10KWp for One Year at 10 Hours Per Day

8. DoD Actions to Expedite Program and Reduce Barriers

Careful FPUP management with immediate attention to procedures for expediting the normal equipment acquisition process should permit DoD to obtain maximum benefits from the program. From the DoD point of view it would appear that the use of P/V energy offers considerable savings in fuel, manpower, and overall operating costs. Photovoltaic power systems offer many other military advantages relative to conventional gasoline driven generators, advantages including quiet, reliable, unattended operation. In wartime when petroleum fuel is a critical item of supply, the use of photovoltaics as an alternative fuel source becomes even more valuable. Hence, it is necessary that DoD make use of the development of photovoltaic energy as a replacement for conventional petroleum fuels in the field of electrical power generation.

Actions which the DoD might take to expedite the Program and obtain maximum benefits are outlined in Exhibit 21. A key initial step would be to build upon the information provided in a "DoD Photovoltaic Energy Conversion Systems Market Inventory and Analysis" by refining the generator inventory data contained in that study. Based on this detailed inventory, applications could be prioritized for conversion to photovoltaic power systems. Those categories of equipment where acceleration of the acquisition process is most easily achieved appear to be in stationary, non-mobile applications such as remote test site instrumentation and communications equipment.

Immediate attention should be directed to expediting the new equipment acquisition programs. Classically, five years are required to complete the steps outlined at the bottom of Exhibit 21. However, it is believed that an expedited effort could reduce this time to 21 months for the acquisition of support equipment such as a photovoltaic power system. Thus prompt initiation of an advanced development program for photovoltaic power systems should permit *delivery* to commence during FY 1979. It is recommended that the DoD establish a high priority, multi-service applications engineering program to accomplish this goal. Such a program must receive adequate funding commensurate with the military potential of the P/V technology (i.e., funding would have to begin in early FY 78 if the FPUP option schedule is to be maintained).

Without the FPUP, photovoltaic equipment is likely to be introduced very slowly within the DoD. This slow utilization would result from the barrier of the classical time required for the acquisition process plus a number of other barriers. For example, DoD budgetary constraints coupled with high front end costs for photovoltaic systems relative to conventional power systems will inhibit rapid introduction of photovoltaics into the DoD. The DoD is not expected to rapidly purchase a new energy technology on the basis of major cost savings over a twenty year life cycle. Also, slower DoD introduction of photovoltaics would lead to more gradual P/V array price declines than those assumed in the analysis. Thus the major cost benefits described in Section D would not be realized. Other barriers to rapid DoD utilization of P/V power systems were described in a DoD Photovoltaic Energy Conversion Systems Market Inventory and Analysis."[19]

CERTAIN BARRIERS TO ADEQUATE DOD MARKET GROWTH RATE WITHOUT FPUP

- DURATION OF CLASSICAL ADUISITION PROCESS (EXPANDED PRESENTATION IN LOWER EXHIBIT).
- LARGE COST EFFECTIVE DOD MARKET CAPTURE POTENTIAL PREMISED ON FIRST ACHIEVING LIFE-CYCLE COST EFFECTIVENESS THROUGH INITIATION OF LOW COST PRODUCTION TECHNIQUES USING EXISTING AUTOMATED TECHNOLOGY.
- LIFE CYCLE COSTING, IN GENERAL, MAY REQUIRE SEVERAL YEARS BEFORE TRANSITION TO FULL ACCEPTANCE BY THE FEDERAL (I.E. EXECUTIVE/LEGISLATIVE) BUDGET PROCESS OCCURS (E.G. 20 YEAR "BUDGET" VS. ANNUAL BUDGET CYCLE).
- LIFE CYCLE COSTING, IN PARTICULAR, NOT YET ACCEPTED THROUGHOUT USER INFRASTRUCTURE; (FPUP, IN NEAR TERM COULD BYPASS SUCH RESISTANCE, AND, IN LONG TERM, LEAD TO USER ACCEPTANCE OF LIFE-CYCLE COSTING)
- NORMAL INSTITUTIONAL RESISTANCE TO ANY NEW PRODUCT -- IRRESPECTIVE OF LIFE-CYCLE OR FIRST COST EFFECTIVENESS
- OTHER BARRIERS DISCUSSED IN REFERENCE NUMBER 1.
- BENEFITS OFTEN DO NOT ACCRUE TO OFFICIAL MAKING EXPENDITURE, E.G., NATIONAL BENEFIT VS. AGENCY COST, O & M, AND FUEL BUDGET CENTER VS. SUPPLY BUDGET CENTER, ETC.
- NATIONAL BENEFITS OFTEN IGNORED

RECOMMENDED DOD ACTIONS TO EXPEDITE PROGRAM

- DEVELOP DETAILED INVENTORY OF DOD GENERATORS BY SIZE/APPLICATION/DUTY CYCLE
- PRIORITIZE APPLICATIONS FOR CONVERSION TO PHOTOVOLTAICS, E.G.
  - REMOTE TEST SITE USES
  - REMOTE COMMUNICATIONS SITES
  - SUBCOMPONENTS OF DOD REMOTE ISLAND POWER SYSTEMS
  - LIGHTING POWER
- ESTABLISH PV SYSTEM PERFORMANCE CRITERIA -- UTILIZING COMMERCIAL GRADE PERFORMANCE CRITERIA WHEREVER POSSIBLE
- ESTABLISH AN ACCELERATED DOD APPLICATIONS ENGINEERING PROGRAM TO PRODUCE FAMILIES OF MILITARY PHTOTVOLTAIC POWER SYSTEMS TO REPLACE CONVENTIONAL SYSTEMS (E.G., 1.5-10KW GASOLINE DRIVEN ENGINE GENERATOR SETS)

TIME FACTORS ACQUISITION PROCESS

STEP	CLASSICAL EFFORT (MO.)	EXPEDITED EFFORT (MO.)
1. LETTER OF AGREEMENT	2	3
2. FUNDING RECEIVED	1	
3. ADVANCED DEVELOPMENT PROGRAM	6	6
4. DEVELOPMENT TESTING	3	
5. OPERATIONAL TEST AND EVALUATION	2	
6. IN PROCESS REVIEW	2	
7. ENGINEERING DEVELOPMENT	15	6-12
8. ENGINEERING TEST	5	
9. IN PROCESS REVIEW	1	
10. CONTRACTS LET	3	6
11. DELIVERY OF PRODUCT	18	
12. ACCEPTANCE TESTING	3	
TOTAL	61	21-27

(1) DOD PHOTOVOLTAIC ENERGY CONVERSION SYSTEMS MARKET INVENTORY AND ANALYSIS

Exhibit 21. Barriers to Adequate DoD Market Growth Rate Without FPUP, Time Factors in the Normal Acquisition Process, and Possible DoD Actions to Expedite FPUP Program

G. PHOTOVOLTAIC POWER SYSTEM DEMONSTRATIONS

Photovoltaic power systems comparable to those required for the FPUP program are already being demonstrated. Two units developed under the ERDA/MERADCOM demonstration program are illustrated in Exhibits 22 and 23. Rapid early identification and development of demonstration units for other comparable applications should aid in reducing system engineering bottlenecks when large volume array delivery begins.

Exhibit 22 shows a portion of the array for a reverse osmosis field water purification unit. The unit requires a 10.7 KWp array for operating power, and it is capable of producing potable drinking water from rivers, lakes, and brackish water sources. Such water purification systems are readily applicable for non-DoD uses, particularly in lesser developed nations.

The photographs in the Exhibit 23 show a tactical field telephone switching system with the array retracted ready to be transported, and with the array unfolded in operating position. Each of the two panels has a 1.2 KWp rating and the total area is 200 square feet. Lead acid batteries provide a 375 amp-hrs of electricity storage at 48 volts for use during periods of low available solar insolation. The use of more tightly packed, higher efficiency solar cells could decrease panel area by a factor of two.

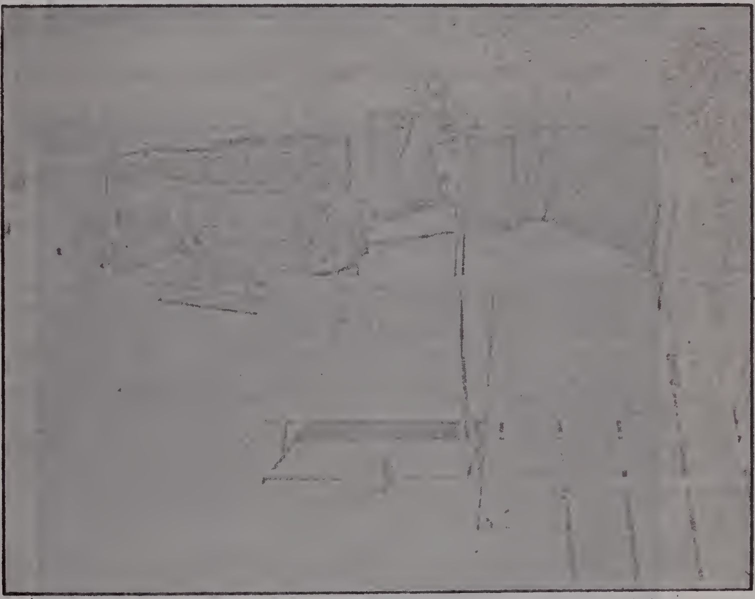


Exhibit 22. Reverse Osmosis Field Water Purification Unit

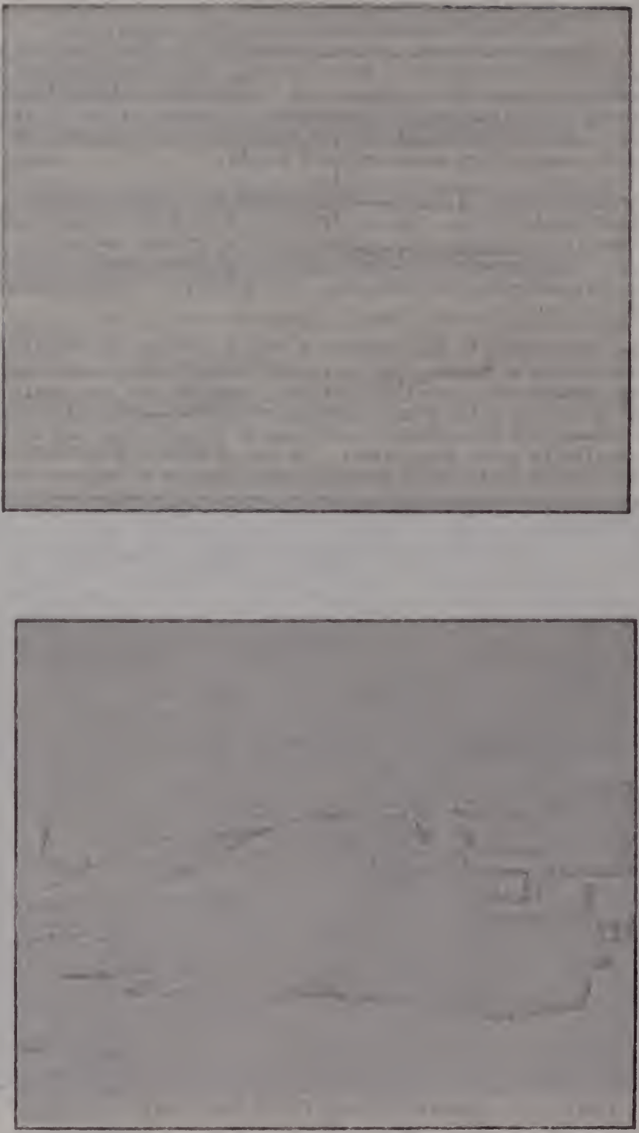


Exhibit 23. Tactical Field Telephone Switching System with the Array Retracted Ready to be Transported, and with the Array Unfolded in Operating Position

REFERENCES

1. "Solar Heating and Cooling of Buildings (SHACOB) Commercialization Report," prepared by Midwest Research Institute for the Federal Energy Administration, July, 1977.

   "The federal government is involved in accelerated commercialization of solar energy because the overall benefits derived from the widespread use of solar energy go beyond the directly calculable economic factors. As stated in the Energy Reorganization Act of 1974 (PL 93-438), Section 2(e):

   > 'Determination of priorities which are warranted should be based on such considerations as power-related values of an energy source, preservation of material resources, reduction of pollutants, export market potential (including reduction of imports), among others. On such a basis, energy sources warranting priority might include, but not be limited to, the various methods of utilizing solar energy'."

2. "DOD Photovoltaic Energy Conversion Systems Market Inventory and Analysis," prepared by the BDM Corporation for FEA/MERADCOM, June, 1977.

3. Private communication with Monsanto, Solar Power, Dow Corning

4. Private communication with Texas Instruments, Dow Corning

5. Private communication with Texas Instruments, GEOS Corporation, Spectrolab

6. Private communications with HAMCO, VARIAN

7. NASA CR-135095: "Demonstration of the Feasibility of Automated Silicon Solar Cell Fabrication," Prepared by Spectrolab, 1976.

8. Spectrolab for FEA: Project Independence Blueprint. RCA's ERDA/JPC 954352-76/3 Automated Array Assembly. Quarterly Report No. 3.

9. Draft Version of RCA's Annual Report to ERDA/JPL.

10. Perspectives on Experience, The Boston Consulting Group, Inc.

11. Letter dated June 21, 1977 from Mr. Anthony W. Adler, Director, Solar Energy Services, Muller and Company, New York to the Honorable Richard L. Ottinger.

12. BDM-Solarex estimates.

13. (Same as 11)

14. "DOD Photovoltaic Energy Conversion Systems Market Inventory and Analysis," prepared by the BDM Corporation for FEA/MERADCOM, June, 1977.

15. "Comparative Analysis of Conceptual Design Studies," B.W. Marshall, Sandia Laboratories, Winter 1977.

16. "Conceptual Design and Systems Analysis of Photovoltaic Systems," Report No. ALO-3686-14, prepared by General Electric Corporation for ERDA, March 1977.

17. Energy Research Digest, July 4, 1977.

18. Federal Energy Administration, Solar Energy Government Buildings Program, A Federal Procurement Plan to Accelerate Use of Solar Energy, prepared by Don Sowle Associates, Inc., December 1976, p. 46.

19. "DOD Photovoltaic Energy Conversion Systems Market Inventory and Analysis," prepared by the BDM Corporation for FEA/MERADCOM, June, 1977.

A SOLAR-HEATED HOSPITAL

(By Ronald Johnson, Reg. Architect, Va., and Donald Crigler, Architect, NAVFAC HQ.)

[From The Naval Civil Engineer, Spring 1977]

Solar energy systems are now being incorporated into the design of the Naval Regional Medical Center here and will provide all water heating, space heating, and up to 100 tons of cooling.

The Naval Regional Medical Center here is in the fiscal year 1977 Military Construction Program and construction will begin in April 1977 with occupancy expected in November 1979. The center will provide 104 beds and 204,000 square feet (19,000 M^2) of space at an estimated cost of $23,850,000. The design contract is administered by South Div, NAVFAC.

The architectural/engineering firm preparing the design is a joint venture of Rogers, Lovelock, and Fritz, Winter Park, Florida; Rogers and Butler, New York City; Lopatka and McQuaig, Winter Park, Florida; and the Wall Corporation, Washington, D.C. Solar energy consultant is Peter Flack and Kurtz, New York City.

SOLAR ENERGY COLLLECTION

Orlando is an ideal location for efficient solar energy systems. Four climatic and geographic factors affect the efficiency of solar energy systems: daily solar radiation, daily cloud cover, air pollution and air moisture content. Solar radiation is measured in Langleys. A Langley denotes one gram calorie per square centimeter or 3.69 BTU's per square foot measured on a horizontal surface.

Mean daily solar radiation in Orlando is 450 Langleys. Mean daily solar radiation in the U.S. varies from 206 Langleys in Alaska to 568 Langleys at China Lake, California. The mean daily cloud cover in Orlando is about 52 percent. The mean daily cloud cover in the U.S. varies from 19 percent at Yuma, Arizona, to a high of 82 percent in Alaska.

Florida has air pollution standards which exceed federal standards and, therefore, has relatively little air pollution. Orlando does have a high air moisture content, especially in summer.

SOLAR ENERGY SYSTEM

To use the sun's energy directly, three major components must be evaluated and designed for any solar energy system. The first is the *Collector* which collects as much solar radiation as possible and converts it into usable energy—such as heat or electricity.

The second is the *Transfer Medium*, the substance used to transfer converted solar energy (heat or electricity) for use or storage. The third component is *Storage*, where converted solar energy is held for later use.

COLLECTOR TYPES

Presently, the only solar collectors economically feasible for use with buildings are those which convert sunlight into heat. In this category are two different types: *Passive Solar Collectors* and *Active Solar Collectors.*

Passive Solar Collectors integrate the collector, transfer medium, and storage to eliminate as many moving parts as possible. The simplest and most common passive solar collector is a south-facing window. Passive collectors are widely used in homes because they provide relatively low temperature heat at minimal cost.

Active Solar Collectors are more complicated and usually connect the three major components of a solar energy system with piping or ductwork. Active solar collectors provide higher energy output and can be separated into three groups: *flat plate collectors*, *tracking concentrating collectors*, and the recently developed *evacuated tubular collectors.*

The *flat plate collector* has been used for 30 to 40 years. It is the simplest and most economical of the three active collectors. It features a metal absorber plate over—or through—which a transfer medium passes and an air space formed by glass cover plates and back insulation to reduce conduction losses.

Absorber plates are now made of aluminum or copper coated with flat black paint or black selective surface. The selective surface produces higher temperatures but costs more. The dead air space acts as a buffer between the absorber plate and the outside air, reducing heat losses.

The glass cover plate produces a "greenhouse effect." It allows short wave solar radiation to enter the collector but prevents long-wave heat energy from leaving. Flat plate collectors use both direct and diffused radiation and are rigidly mounted facing south.

To achieve the temperatures needed for solar cooling, flat plate collectors can be augmented with reflectors to increase radiation on the absorber plate.

Tracking concentrating collectors produce high temperatures for special applications. By concentrating the sun's rays on a single point or line, this collector can produce temperatures up to 7,000° F. (3,871°C).

Concentrating collectors for buildings can heat a transfer fluid to 240°F. (116°C). This is the normal operating temperature of a steam absorption chiller for solar cooling. One drawback of the tracking concentrating collector is that it only uses direct radiation and must always face the sun. This makes necessary a mechanical device which increases initial cost and maintenance substantially.

The evacuated tabular collector is a relatively new development which uses both direct and diffused solar radiation and can be rigidly mounted. It features concentric tubes with a vacuum between them. The inner tube, through which the liquid flows, is coated with a selective surface.

The vacuum between the two tubes is sufficient to eliminate practically all conduction and convection heat losses, increasing efficiency. Temperatures to 240°F (116°c) can be reached for a steam absorption chiller for solar cooling. The cost of this collector is relatively high and it is available on special order only.

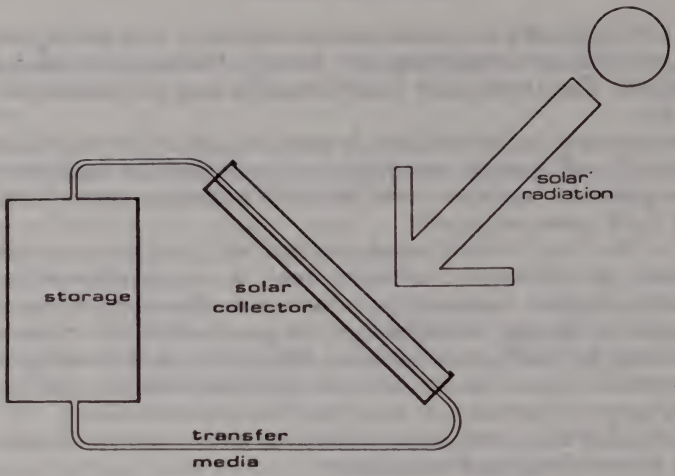
TRANSFER MEDIA

Two factors should be considered in selecting a transfer medium. First is local climatic conditions and second, the function solar energy is to perform. The three basic transfer media are: air, water, and heat transfer oils.

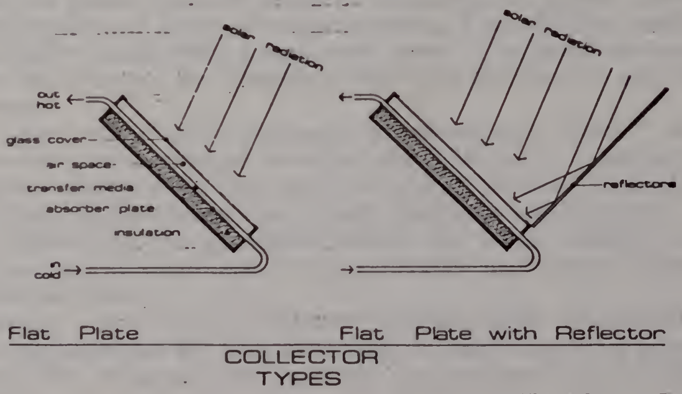
Air, as a heat transfer medium, is used mainly in homes where cost, maintenance, and quickly available low temperature heat are major design factors. Air systems need more installation space because of the large duct space required.

Water is the most widely used medium and, unlike air, needs only small tubes to collect and transfer heat. A water system can also attain much higher temperatures than air. Freezing, however, becomes a major design consideration in more northern climates but can be solved by adding anti-freeze; design of a self-draining system which empties when not in use; or by thermostat controls which activate pumps to circulate warm water to the collector.

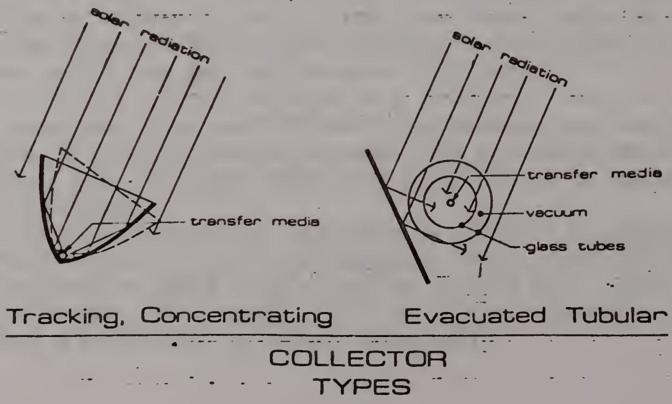
Heat transfer oils have been tested for solar energy systems, but have not met wide-spread acceptance.



Basics of solar energy systems



Above and below: collector types



STORAGE

Two types of storage media are now used for solar energy systems: rock storage and water storage.

Rock storage is common for home use with air as the transfer medium. Rocks do not store as much heat at a given temperature per unit of volume as water and more space is needed to provide the same heat storage capabilities.

Water storage is the most widely used medium because of its high specific heat. When used with water as the transfer medium, water storage eliminates the need for heat exchangers, improving overall efficiency.

SYSTEM EFFICIENCY

Solar energy system efficiency is determined by the efficiency of the three main components: the collector, the transfer medium, and storage. Collector efficiency is affected by three factors: radiation received by the collector, temperature difference between the collector and ambient air, and wind velocity.

Radiation received by the collector is affected by reflectivity of the glass cover and the amount of reflected radiation striking the collector. Reflectivity of the glass cover and the amount of reflected radiation striking the collector can be optimized through design for a given collector type.

The reflectivity of the glass cover is determined by the angle at which the collector is mounted relative to the sun. A solar collector should be set perpendicular to the sun's rays during the season of highest energy need. If the collector is to provide heat during winter months inclination should be perpendicular to the sun's winter rays. This minimizes solar energy reflected off the glass cover when energy is most needed.

Reflected radiation striking the collector can increase operating efficiency. Placing a reflective surface near the collector will direct more solar energy onto the collector.

Heat loss from a collector and the temperature difference between the collector and ambient air are directly related. As the temperature difference increases so does heat loss. Two reasons collectors work better in summer than winter are reduced temperature differences between collectors and ambient air, and reduced wind velocities.

Transfer media and storage efficiency are affected by two factors: heat lost to the ambient air, and heat lost in the exchange from transfer to storage. Heat lost to ambient air can be controlled by insulation and reducing the distance the transfer media must travel.

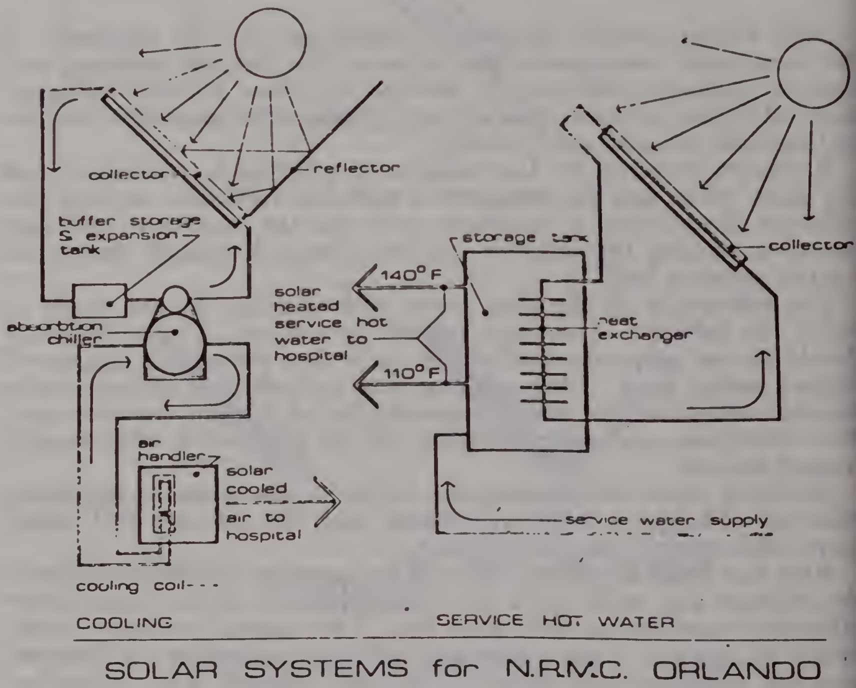
Heat is also lost whenever a heat exchanger is introduced into the system. When heat is transferred from one medium to another, energy is lost in the exchange. Heat exchangers are normally kept at a minimum for most efficient system operation.

NRMC ORLANDO

The system selected for NRMC Orlando will have about 1,500 ft^2 (14m^2) of flat plate collectors for hot water and space heating, and some 8,500 ft^2 (790m^2) of flat plate collectors with reflectors for cooling. Flat plate collectors will be integrated into the center's design.

Flat plate collectors for hot water and space heating will be on the roof of the second floor and slope up to the fourth floor. The third floor is a mechanical equipment floor. Flat plate collectors with reflectors for cooling will be on the roof of the large one-story portion of the building. The transfer and storage medium will be water. Freezing will be prevented by circulating small amounts of warm water through the system.

Flat plate collectors with reflectors will provide temperatures up to 180°F (82°C) for operating a derated absorption chiller. Cost of the solar system will be about $450,000 or 2 percent of the total building cost. Fuel oil savings are estimated at 600,000 to 1,000,000 gallons (2,300,000 to 3,800,000 liters) over 50 years.



Dual.—Two solar systems have been proposed for NRMC Orlando. One collector serves to provide moderately hot water for heating and normal hot water uses. Another collector augmented with reflectors serves to provide hotter water to be used in an absorption chiller for air conditioning.

THE SOLAR AGE

The solar energy age has arrived, and technology should be used to develop the maximum potential for use of solar energy. Until recently, low cost energy from fossil fuels has suppressed solar energy development. However, with rising costs and the diminishing supply of fossil fuels, this country is slowly turning to solar energy.

NAVFAC feels the solar energy system proposed for the Naval Regional Medical Center, Orlando is a small, but necessary, step toward use of solar energy systems. Documentation of this system will provide a data base for improving the efficiency of future solar energy systems and, hopefully, go a long way toward improving current solar energy technology.

C. OIL IMPORT QUOTAS AND FEES

Supreme Court Decision: Algonquin SNG v. FEA

[From Federal Energy Guidelines]

Algonquin SNG, Inc., et al. v. Federal Energy Administration, et al. (originally *Massachusetts v. Simon* (¶ 26,012)), U. S. Supreme Court, Dkt. No. 75–382, June 17, 1976.

PROCLAMATION NO. 4341

Subject: Validity of License Fees on Oil Imports

Facts and arguments. In response to an increasing domestic reliance on foreign oil, President Nixon, in May 1973, established a per-barrel fee schedule on imported crude oil that was to start at 10.5¢ per barrel on May 1, 1973, to 21¢ per barrel on May 1, 1975. With respect to most finished petroleum products, the fee was to rise gradually from 15¢ per barrel on May 1, 1973, to 63¢ per barrel by November 1, 1975. Finding that these fees were insufficient to discourage imports, and acting in accordance with an advisement by the Secretary of the Treasury that a high degree of oil imports could endanger national security, President Ford initiated a supplemental import fee program that was to start at $1.00 per barrel of crude oil the first month, rise to $2.00 per barrel of crude and 60¢ per barrel of refined products the second month, and to $3.00 for crude and $1.20 for refined products the third month. The supplemental fees actually never rose beyond $2.00 per barrel of crude and 60¢ per barrel of refined products, and they were removed by President Ford when he signed the Energy Policy and Conservation Act in December 1975.

Algonquin SNG and a number of other New England utilities and Massachusetts and some other northeastern states that are heavily dependent on imported oil joined to ask that the Administration be enjoined from collecting the fees because, they alleged, the President's power to restrict imports is limited to the imposition of quotas. While a federal district court ruled in favor of the government, the Court of Appeals for the District of Columbia reversed, contending that the Administration's import authority is limited to direct controls, such as quotas, and does not extend to such indirect control procedures as license fees.

Supreme Court opinion.—In a unanimous decision, the Supreme Court reversed the Court of Appeals. In authorizing the President to take such action as he deems necessary to adjust imports into the United States for national security reasons, Congress, in the Trade Expansion Act, gave him the power to impose import fees on commodities such as oil. The Supreme Court noted that the President's authority to adjust imports should not be read to encompass only quantitative methods (quotas) as opposed to monetary methods (fees) in effecting the adjustment. To do so would limit the word "adjust" in a manner contemplated neither by the wording of the act nor by legislative history, the court said.

The full text of the Supreme Court opinion follows:

Mr. Justice Marshall delivered the opinion of the Court.

Section 232(b) of the Trade Expansion Act of 1962, Pub. L. No. 87–794, 76 Stat. 877, as amended by § 127(d) of the Trade Act of 1974, Pub. L. No. 93–618, 88 Stat. 1993, 19 U.S.C. § 1862(b) (Supp. IV), provides that if the Secretary of the Treasury finds that an "article is being imported into the United States in such quantities or under such circumstances as to threaten to impair the national security," the President is authorized to

> "take such action, and for such time, as he deems necessary to adjust the imports of [the] article and its derivatives so that . . . imports [of the article] will not threaten to impair the national security."[1]

All parties to this case agree that § 232(b) authorizes the President to adjust the imports of petroleum and petroleum products by imposing quotas on such imports. What we must decide is whether § 232(b) also authorizes the President to control such imports by imposing on them a system of monetary exactions in the form of license fees.

I

The predecessor statute to § 232(b) was originally enacted by Congress as part of the Trade Agreements Extension Act of 1955, Pub. L. No. 84–86, § 7, 69 Stat. 166, see n. 21, *infra,* and amended by the Trade Agreements Extension Act of 1958. Pub. L. No. 85–686, § 8, 72 Stat. 678. The advisory function currently performed under § 232(b) by the Secretary of the Treasury was performed by the Director of the Office of Defense Mobilization (ODM) under the 1955 and 1958 statutes. But, like § 232(b), those statutes allowed the President, on a finding that imports of an article were threatening "to impair the national security," to "take such action as he deem[ed] necessary to adjust the imports of [the] article. . . ." In 1959, President Eisenhower, having been advised by the Directo of ODM that "crude oil and the principal crude oil derivatives and products are being imported in such quantities and under such circumstances as to threaten to impair the national security," invoked the 1958 version of the provision and established the Mandatory Oil Import Program (MOIP). Pres. Proc. 3279, 24 Fed. Reg. 1781. The MOIP, designed to reduce the gap between domestic supply and demand by encouraging the development of domestic production and refiner capacity, imposed a system of quotas on the importation of petroleum and petroleum products. The program was not wholly successful, however, and in the fac of domestic consumption which continued to grow faster than domestic production, Presidents Kennedy, Johnson, and Nixon each felt compelled to amend it by raising the permissible quota levels. App., at 211–212.

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[1] Section 232(b) provides in full:

"Upon request of the head of any department or agency, upon application of an interested party, or upo his own motion, the Secretary of the Treasury (hereinafter referred to as the 'Secretary') shall immediatel make an appropriate investigation, in the course of which he shall seek information and advice from, an shall consult with, the Secretary of Defense, the Secretary of Commerce, and other appropriate officers o the United States, to determine the effects on the national security of imports of the article which is the subject of such request, application, or motion. The Secretary shall, if it is appropriate and after reasonabl notice, hold public hearings or otherwise afford interested parties an opportunity to present informatio and advice relevant to such investigation. The Secretary shall report the findings of his investigation unde this subsection with respect to the effect of the importation of such article in such quantities or under suc circumstances upon the national security and, based on such findings, his recommendation for action or inaction under this section to the President within one year after receiving an application from an intereste party or otherwise beginning an investigation under this subsection. If the Secretary finds that such articl is being imported into the United States in such quantities or under such circumstances as to threate to impair the national security, he shall so advise the President and the President shall take such actio and for such time, as he deems necessary to adjust the imports of such article and its derivatives so tha such imports will not threaten to impair the national security, unless the President determines that tha article is not being imported into the United States in such quantities or under such circumstances a to threaten to impair the national security."

Section 232(c) of the Act, 19 U.S.C. § 1862(c) (Supp. IV) provides the President and the Secretary of th Treasury with guidance as to some of the factors to be considered in implementing § 232(b). It provide

"For the purposes of this section, the Secretary and the President shall, in the light of the requirement of national security and without excluding other relevant factors, give consideration to domestic productio needed for projected national defense requirements, the capacity of domestic industries to meet such requir ments, existing and anticipated availabilities of the human resources, products, raw materials, and othe supplies and services essential to the national defense, the requirements of growth of such industries an such supplies and services including the investment, exploration, and development necessary to assure suc growth, and the importation of goods in terms of their quantities, availabilities, character, and use as tho affect such industries and the capacity of the United States to meet national security requirements. In th administration of this section, the Secretary and the President shall further recognize the close relation of th economic welfare of the Nation to our national security, and shall take into consideration the impact foreign competition on the economic welfare of individual domestic industries; and any substantial u employment, decrease in revenues of government, loss of skills or investment, or other serious effects resul ing from the displacement of any domestic products by excessive imports shall be considered, without e cluding other factors, in determining whether such weakening of our internal economy may impair the n tional security."

In light of a Cabinet task force conclusion that the MOIP, as then constituted, was not fulfilling its objectives,[2] President Nixon, acting pursuant to §232(b), radically amended the program in 1973. Pres. Proc. 4210, 38 Fed. Reg. 9645. The President suspended existing tariffs on oil imports and provided "for a gradual transition from the existing quota method of adjusting imports of petroleum and petroleum products to a long-term program for adjustment of imports of petroleum and petroleum products through . . . the institution of a system of fees applicable to imports of crude oil, unfinished oils and finished products. . . ." *Id.*, at 9646. This amended program established a gradually increasing schedule of license fees for importers. With respect to crude oil, the fee was scheduled to increase from an initial 10½ cents per barrel on May 1, 1973 to 21 cents per barrel on May 1, 1975. With respect to most finished petroleum products, the fee was to rise gradually from 15 cents per barrel on May 1, 1973 to 63 cents per barrel on November 1, 1975.[3] *Id.*, at 9649. While initially some oil imports were exempted from the license fee requirements, the exemption levels were scheduled to decrease annually so that by 1980 the fees would be applicable to all oil imports.

President Nixon's 1973 program apparently did not wholly fulfill the objectives to which it was directed. Accordingly, the Secretary of the Treasury, acting pursuant to § 232(b), see n. 1, *supra*, initiated an investigation on January 4, 1975, "to determine the effects on the national security of imports of petroleum and petroleum products." Memorandum from Secretary of the Treasury Simon to Assistant Secretary of the Treasury MacDonald (Simon Memorandum), App., at 154. While § 232(b) directs the Secretary "if it is appropriate [to do so, to] hold public hearings or otherwise afford interested parties an opportunity to present information and advice" as part of such an investigation, 19 U.S.C. § 1862(b), the Secretary found that such procedures would interfere with "national security interests" and were "inappropriate" in this case. Simon Memorandum, App., at 154. The investigation therefore proceeded without any public hearing or call for submissions from interested nongovernmental parties.

The Secretary submitted a report on his investigation to President Ford on January 14, 1975. Intimating that the measures then in force under § 232(b) had indeed not solved the problems to which they were directed, the Secretary indicated that the United States' dependence on foreign oil had continued to increase since 1966 and that foreign sources currently accounted for well over a third of domestic consumption. The Secretary concluded that:

> "crude oil, principal crude oil derivatives and products, and related products derived from natural gas and coal tar are being imported into the United States in such quantities as to threaten to impair the national security [and] the foregoing products are being imported into the United States under such circumstances as to threaten to impair the national security." App., at 133.

On the basis of these findings, the Secretary recommended to the President that:

> "appropriate action be taken to reduce imports of crude oil, principal crude oil derivatives and products, and related products derived from natural gas and coal tar into the United States. . . ." *Ibid.*

The President agreed with the findings of the Secretary's investigation and concluded that it was "necessary and consistent with the national security to further discourage importation into the United States of petroleum, petroleum products, and related products. . . ." Pres. Proc. 4341, 40 Fed. Reg. 3965 (1975). Invoking § 232(b), he issued a proclamation on January 23, 1975, which, effective immediately, raised the so-called "first-tier" license fees that were imposed in 1973, see pp. 4–5, *supra*, to the maximum levels previously scheduled to be reached only some months later.[4] Pres. Proc. 4341, 40 Fed. Reg. 3965. The proclamation also imposed on all imported oil, whether covered by the first-tier fees or not, a supplemental fee of $1 per barrel for oil entering the United States on or after February 1, 1975. The supplemental fee was scheduled to rise to $2 a barrel for oil entering after March 1, 1975, and to $3 per barrel for oil entering after April 1, 1975.[5] Finally, the proclamation reinstated the tariffs that had been suspended in

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[2] See Cabinet Task Force on Oil Import Control, The Oil Import Question, p. 128 (1970).

[3] Under President Nixon's plan, motor gasoline was scheduled to reach its maximum fee of 63 cents on May 1, 1975. App., at 97.

[4] The proclamation did not alter the schedule by which exemptions from the first-tier fees were not to be eliminated until 1980.

[5] The supplemental fee increases scheduled to go into effect in March and April were twice deferred. See Pres. Proc. 4355, 40 Fed. Reg. 10437 (1975); Pres. Proc. 4370, 40 Fed. Reg. 19421 (1975). While the $2 fee finally went into effect on June 1, 1975, Pres. Proc. 4377, 40 Fed. Reg. 23429, it was never increased to $3. Indeed, on January 3, 1976, President Ford eliminated the $2 fee. Pres. Proc. 4412, 41 Fed. Reg. 1037. See n. 8, *infra*.

April 1973. Soon after issuance of the proclamation, the Federal Energy Administration (FEA) amended its oil import regulations in order to implement the new program. 40 Fed. Reg. 4771–4776 (1975).

Four days after the proclamation was issued, respondents—eight States and their governors,[6] 10 utility companies,[7] and Congressman Robert P. Drinan of Massachusetts—challenged the license fees in two suits filed against the Secretary of the Treasury, the Administrator of FEA and the Treasurer of the United States in the United States District Court for the District of Columbia. Seeking declaratory and injunctive relief, they alleged that the imposition of the fees was beyond the President's constitutional and statutory authority, that the fees were imposed without necessary procedural steps having been taken, and that petitioners (hereinafter the Government) violated the National Environmental Policy Act (NEPA), 42 U.S.C. §§ 4321 *et seq.*, by failing to prepare an environmental impact statement prior to the imposition of the fees.

The District Court denied respondents' motions for preliminary injunctions and filed findings of fact and conclusions of law which, at the request of respondents, it later declared to be final. See 518 F. 2d 1064 (1975) (appendix to dissenting opinion in Court of Appeals). The court found that § 232(b) is a valid delegation to the President of the power to impose license fees on oil imports. 518 F. 2d, at 1066–1067. It further ruled that the procedures followed by the President and the Secretary of the Treasury in imposing the license fees fully conformed to the requirements of the statute. *Id.*, at 1068. Finally, the court held that "in view of the emergency nature of the problem and the need for prompt action," *id.*, at 1069, the Government was not required to file an environmental impact statement prior to imposition of the fees and hence was not in violation of NEPA. *Ibid.*

Respondents' appeals from these judgments were consolidated with their petitions to the Court of Appeals for the District of Columbia Circuit for review of the FEA regulations implementing the license fee program. The allegations in the challenges to the regulations were substantially the same as those raised in the District Court actions, adding only a contention that the FEA had failed to follow certain procedural provisions of the Federal Energy Administration Act, 15 U.S.C. §§ 761 *et seq.* The Court of Appeals, with one judge dissenting, held that § 232(b) does not authorize the President to impose a license fee scheme as a method of adjusting imports. 518 F. 2d 1051 (1975). According to the court, reading the statute to authorize the action taken by the President "would be an anomalous departure" from "the consistently explicit, well-defined manner in which Congress has delegated control over foreign trade and tariffs." *Id.*, at 1055. In the court's view, § 232(b)'s legislative history indicated that Congress' authorization of the President to "adjust the imports of [an] article" encompassed only the use of "direct" controls such as quotas and did not encompass the use of license fees. *Id.*, at 1059. Finding no need to address any of the other issues that were raised, the court reversed the judgment of the District Court, instructed that court to enter appropriate relief for respondents, and set aside the challenged FEA regulations.

We granted the Government's petition for certiorari, 423 U.S. 923 (1975),[8] and now reverse. Both the language of § 232(b) and its legislative history lead us to conclude that it authorizes the action taken by the President in this case.[9]

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[6] The States joining in the suit together with their governors were Connecticut, Maine, Massachusetts, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont. The State of Minnesota intervened as a plaintiff after the complaint was filed and is also a respondent here.

[7] The 10 utility companies are Algonquin SNG, Inc., New England Power Co., New Bedford Gas and Edison Light Co., Cambridge Electric Light Co., Canal Electric Co., Montaup Electric Co., Connecticut Light and Power Co., Hartford Electric Light Co., Western Massachusetts Electric Light Co., and Holyoke Water Co.

[8] Subsequent to our granting certiorari, the President signed the Energy Policy and Conservation Act of 1975, Pub. L. 94–163, 89 Stat. 871. The Act is aimed at encouraging domestic oil production by gradually decontrolling the price of domestically produced crude oil. On January 3, 1976, indicating that "the purposes of the supplemental [oil import license] fee" will be served by the Act, the President announced the elimination of the supplemental fees imposed by Presidential Proclamation 4341. Pres. Proc. 4412, 41 Fed. Reg. 1037. He did not, however, eliminate the "first-tier" fees originally imposed by Presidential Proclamation 4210. Since respondents seek to enjoin the first-tier as well as the supplemental fees, the question here whether § 232(b) grants the President authority to impose license fees remains a live controversy.

[9] Respondents' suits are not barred by the Anti-Injunction Act, 26 U.S.C. § 7421(a), which in relevant part provides that "no suit for the purpose of restraining the assessment or collection of any tax shall be maintained in any court by any person . . ." The Anti-Injunction Act applies to suits brought to restrain assessment of taxes assessable under the Internal Revenue Codes of 1954 and 1939. 26 U.S.C. §§ 7421(a), 7851(a)(6)(A), 7851(a)(6)(C)(iv). The license fees in this case are assessed under neither Code but rather under the authority conferred on the President by the Trade Expansion Act of 1962, as amended by the Trade Act of 1974. The fees are therefore not "taxes" within the scope of the Anti-Injunction Act.

II

A. Preliminarily, we reject respondents' suggestion that we must construe § 232(b) narrowly in order to avoid "a serious question of unconstitutional delegation of legislative power." Respondents' Brief, at 42. Even if § 232(b) is read to authorize the imposition of a license fee system, the standards that it provides the President in its implementation are clearly sufficient to meet any delegation doctrine attack.

In *Hampton & Co. v. United States*, 276 U.S. 394 (1928), this Court upheld the constitutionality of a provision empowering the President to increase or decrease import duties in order to equalize the differences between foreign and domestic production costs for similar articles. There, the Court stated:

> "If Congress shall lay down by legislative act an intelligible principle to which the [President] is directed to conform, such legislative action is not a forbidden delegation of legislative power." *Id.*, at 409.

Section 232(b) easily fulfills that test. It establishes clear preconditions to Presidential action—*inter alia,* a finding by the Secretary of the Treasury that an "article is being imported into the United States in such quantities or under such circumstances as to threaten to impair the national security." Moreover, the leeway that the statute gives the President in deciding what action to take in the event the preconditions are fulfilled is far from unbounded. The President can act only to the extent "he deems necessary to adjust the imports of such article and its derivatives so that such imports will not threaten to impair the national security." And § 232(c), see n. 1, *supra*, articulates a series of specific factors to be considered by the President in exercising his authority under § 232(b).[10] In light of these factors and our recognition that "[n]ecessity . . . fixes a point beyond which it is unreasonable and impracticable to compel Congress to prescribe detailed rules . . ." *American Power & Light Co. v. Securities & Exchange Commission*, 329 U.S. 90, 105 (1946), we see no looming problem of improper delegation [11] that should affect our reading of § 232(b).

B. In authorizing the President to "take such action, and for such time, as he deems necessary to adjust the imports of [an] article and its derivatives," the language of § 232(b) seems clearly to grant him a measure of discretion in determining the method to be used to adjust imports. We find no support in the langrage of the statute for respondent's contention that the authorization to the President to "adjust" imports should be read to encompass only quantitative methods—i.e., quotas—as opposed to monetary methods—i.e., license fees—of effecting such adjustments.

Indeed, reading respondents' suggested limitation into the word "adjust" would be inconsistent with the range of factors that can trigger the President's authority under § 232(b)'s language. Section 232(b) authorizes the President to act after a finding by the Secretary of the Treasury that a given article is being imported "in such quantities or *under such circumstances* as to threaten to impair the national security." (Emphasis added.) The emphasized language reflects Congress' judgment that "not only the quantity of imports . . . but also the circumstances under which they are coming in: their use, their avaliability, their character" could endanger the national security and hence should be a potential basis for

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[10] Respondents rely on our decision in *National Cable Television Assn. Inc. v. United States*, 415 U.S. 336 (1974), to support their delegation doctrine Argument. But we find that case clearly distinguishable from the one before us today. In *National Cable Television*, we held that the fees to be imposed on community antenna television systems should be measured by the "value to the recipient" even though the language of the general statute allowing fee-setting by federal agencies, 31 U.S.C. § 483(a), permits consideration not only of "value to the recipient" but also of "public policy or interest served, and other pertinent facts." *Ibid.* The Court's conclusion that the words of the last-quoted phrase were not relevant to the CATV situation was apparently motivated by a desire to avoid any delegation doctrine problem that might have been presented by a contrary conclusion. 415 U.S., at 342. But what might be considered the openended nature of the phrase "public policy or interest served, and other pertinent facts" stands in contrast of § 232(b)'s more limited authorization of the President to act only to the extent necessary to eliminate a threat of impairment to the national security, and § 232(b)'s articulation of standards to guide the President in making the decision whether to act. See n. 1, *supra*.

[11] The amount of oil exempted from the "first-tier" license fees, see p. 5, *supra*, imposed in 1973 varies among five geographical districts within the Nation. See Pres. Proc. 4341, 40 Fed. Reg. 3965 (1975), Pres. Proc. 4210, 38 Fed. Reg. 9645 (1973). Respondents seize on this fact to argue that the "first-tier" fee schedule contravenes Art. I, § 8, cl. 1, of the Constitution which requires that import duties be uniform throughout the United States. But that issue is not properly before the Court. Sustaining respondents' uniformity clause argument would call not for invalidation of the entire license fee scheme, but only for elimination of the geographical differences in the exemptions allowed under it. This would represent not an affirmance of the judgments below, which effectively invalidated the entire scheme and its implementing regulations, but rather a modification of those judgments. But since respondents filed no cross-petition for certiorari, they are at this point precluded from seeking such modification. See *Mills v. Electric Auto-Lite Co.*, 396 U.S. 375, 381 n. 4 (1970).

Presidential action. 104 Cong. Rec. 10542–10543 (1958) (remarks of Rep. Mills). It is most unlikely that Congress would have provided that dangers posed by factors other than the strict quantitative level of imports can justify Presidential action, but that that action must be confined to the imposition of quotas. Unless one assumes and we do not, that quotas will always be a feasible method of dealing directly with national security threats posed by the "circumstances" under which imports are entering the country, limiting the President to the use of quotas would effectively and artificially prohibit him from directly dealing with some of the very problems against which § 232(b) is directed.

Turning from § 232's language to its legislative history, again there is much to suggest that the President's authority extends to the imposition of monetary exactions—*i.e.*, license fees and duties. The original enactment of the provision in 1955 as well as Congress' periodic reconsideration of it in subsequent years gives us substantial grounds on which to conclude that its authorization extends beyond the imposition of quotas to the type of action challenged here.

During congressional hearings on the Trade Agreements Extension Act of 1955, there was substantial testimony that increased imports were threatening to damage various domestic industries whose viability was perceived to be critical to the national security.[12] In an effort to deal with the problem, the Senate Committee on Finance considered several proposals designed to supplement the existing statutory provision, known as the Symington Amendment,[13] that barred reductions in duties "on any article if the President finds that such reduction would threaten domestic production needed for projected national defense requirements." Act of July 1, 1954, Pub. L. No. 83–464, § 2, 68 Stat. 360.[14] Among these amendments was one proposed by Senator Neely which provided in relevant part:

> "[T]he President shall take *such action as is necessary* to restrict imports of commodities whenever such imports threaten to retard the domestic development and expansion or maintenance of domestic production of natural resource commodities or any other commodities which he determines to be essential to the national security. . . ." Hearings on H.R. 1 before the Senate Committee on Finance, 84th Cong., 1st Sess., 1033 (1955) (hereinafter cited as 1955 Senate Hearings) (emphasis added).[15]

In explaining what action would be authorized under the Neely amendment, Senator Martin, one of its co-sponsors, explained that it authorized the President "to take such action as is necessary, including the imposition of import quotas *or the increase in duties*, to protect the domestic industry concerned." 1955 Senate Hearings, at 2097 (emphasis added). Thus, the Neely amendment clearly would have given the President the authority to impose monetary exactions as a method of restricting imports.

While the Neely amendment was not reported out of committee, it is strikingly similar in language to the Byrd-Millikin amendment—the substitute provision that was reported out and eventually enacted into law. The Byrd-Millikin amendment authorized the President, after appropriate recommendations had been made by the Director of the Office of Defense Mobilization, to "take such action as he deems necessary to adjust the imports of [an] article to a level that will not threaten to impair the national security." S. Rep. No. 242, 84th Cong., 1st Sess., 14 (1955).[16] (Emphasis added.) Given the similarity in the operative language of the two proposals, it is fair to infer that if, as Senator Martin stated, the Neely amendment was intended to authorize the imposition of monetary exactions, so too was the Byrd-Millikin amendment.

The debate on the Senate floor lends further support to this reading of the Byrd-Millikin amendment. Senator Millikin himself stated without contradiction that the amendment authorized the President "to take whatever action he deems necessary to adjust imports [including the use of] tariffs, quotas, import taxes or other methods of import restriction." 101 Cong. Rec. 5299 (1955). As a statement of one of the legislation's sponsors, this explanation deserves to be accorded substantial weight in interpreting the statute. *National Woodworkers Manufacturers Assn. v. NLRB,* 386 U.S. 612, 460 (1967); *Schwegmann Bros. v. Calvert Distillers Corp.,* 341 U.S. 384, 394–395 (1951).[17]

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[12] See, *e. g.*, Hearings on H.R. 1 before the House Committee on Ways and Means, 84th Cong., 1st Sess. 1006 (analytical balance industry), 1264 (petroleum industry) (1955); Hearings on H. R. 1 before the Senate Committee on Finance, 84th Cong., 1st Sess., 602 (lead and zinc mining industry), 721 (coal mining industry) (1955).

[13] The Symington amendment is currently codified in somewhat modified form at 19 U.S.C. § 1862(a).

[14] In contrast to the Senate Committee on Finance, the House Committee on Ways and Means concluded that the Symington amendment was adequate to deal with any potential threats to the national security posed by foreign imports. H.R. Rep. No. 50, 84th Cong., 1st Sess., 44 (1955).

[15] A separate portion of the Neely amendment would have placed quotas on petroleum imports. 1955 Senate Hearings, at 1033.

[16] Unlike the Neely amendment, see n. 15, *supra*, the Byrd-Millikin amendment did not single out any named industries for protection by quotas.

Senator Millikin's statement does not stand alone. Senator Byrd, another of the amendment's sponsors, explained in colloquy with Senator Saltonstall that the amendment put all commodities "*on the same basis as agricultural commodities.* It simply leaves to the President the power, in his discretion, to decide whether to impose a quota or to reduce the imports." 101 Cong. Rec. 5297 (1955) (emphasis added). The reference in the emphasized phrase is to § 22 of the Agricultural Adjustment Act, the subject of an earlier exchange between Senator Byrd and Senator Thye. 101 Cong. Rec. 5296 (1955). Section 22 allows the President under certain circumstances to "*impose such fees* . . . or such quantitative limitations" as he finds necessary to protect the domestic production of an agricultural commodity. 7 U.S.C. § 624(b) (emphasis added). Senator Byrd's comparison of § 22 and the Byrd-Millikin amendment thus appears to reflect his understanding that Presidential authority under the amendment extended to the imposition of fees.[18]

Finally, we note two other statements on the floor of the Senate which lend direct support to the Government's reading of the Byrd-Millikin amendment. Senator Bennett stated that it was his understanding that the amendment would authorize use of "the entire scope of tariffs, quotas, restrictions, stockpiling, and any other variation of these programs in order to protect a particular industry." 101 Cong. Rec. 5588 (1955).[19] And Senator Barkley, a member of the Senate Committee on Finance, expressed his understanding that the amendment would allow the President to "impose such quotas *or take such other steps* as he may believe to be desirable in order to maintain the national security." *Id.,* at 5298 (emphasis added).

In the House debate following Senate passage of the Byrd-Millikin amendment, 101 Cong. Rec. 5655 (1955), and its acceptance with a minor modification by the House conferees, H.R. Conf. Rep. No. 745, 84th Cong., 1st Sess., 2, 6–7 (1955), we find further indications that the amendment authorized the imposition of monetary exactions. In explaining the provisions of the amendment, Congressman Cooper, chairman of the House Ways and Means Committee and a member of the conference committee, indicated his concern that "*any modification of a duty* on imports or a quota would [because of retaliation from abroad] inevitably result in a curtailment of exports by the United States." 101 Cong. Rec. 8161 (1955) (emphasis added). Furthermore, as part of his explanation of the amendment, Cooper presented a letter he had received from Gerald D. Morgan, Special Counsel to the President, which expressed the Administration's understanding that under the amendment, the President's action to adjust imports "could take any form that was appropriate to the situation." 101 Cong. Rec. 8162 (1955).[20] Thus, when Congress finally enacted the Byrd-Millikin amendment's national security provision, 69 Stat. 166,[21] as part of the Trade Agreement Extension Act of 1955, not only had Members of both Houses indicated that the provision authorized the imposition of monetary exactions, but the Executive Branch too had advised the Congress of its understanding of the broad scope of the authority granted by the amendment.[22]

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[17] Differing with the Court of Appeals, we do not believe that the fact that Senator Milikin represented a State that might have benefited from an expansive reading of the statute "blur[s] [the] probative value." 518 F. 2d. at 1058, of his explanation. Many if not most pieces of legislation are sponsored by Members of Congress whose constituents have a special interest in their passage, but we have never let this fact diminish the weight we give a sponsor's statements.

[18] Moreover, Senator Byrd's reference in the above-quoted exchange to the power of the President under the amendment "to impose a quota *or* to reduce the imports." 101 Cong. Rec. 5297 (1955), also suggests that he understood that power to extend beyond the imposition of quotas. See Note, 89 Harv. L. Rev. 432, 435 n. 31 (3975).

[19] The Court of Appeals characterized Senator Bennett's remarks as going to "the entire bill and other existing laws." 518 F. 2d, at 1057. Our examination of the context of his remarks persuades us. however, that they were more probably made in specific reference to the Byrd-Millikin amendment.

[20] A copy of the Morgan letter was also sent to Senator Byrd, Chairman of the Senate Committee on Finance. See 101 Cong. Rec. 8162 (1955).

[21] As finally enacted the amendment provided:

"In order to further the policy and purposes of this section, whenever the Director of the Office of Defense Mobilization has reason to believe that any article is being imported into the United States in such quantities as to threaten to impare the national security, he shall so advise the President, and if the President agrees that there is reason for such belief, the President shall cause an immediate investigation to be made to determine the facts. If, on the basis of such investigation, and the report to him of the findings and recommendations made in connection therewith, the President finds that the article is being imported into the United States in such quantities as to threaten to impair the national security, he shall take such action as he deems necessary to adjust the imports of such article to a level that will not threaten to impair the national security."

Three years later, in the context of its consideration of the Trade Agreements Extension Act of 1958, Congress re-examined the Byrd-Millikin national security provision. In the course of its deliberations, the Subcommittee on Foreign Trade Policy of the House Ways and Means Committee had before it a 1957 report submitted to it by the Office of Defense Mobilization, expressing the views of the Executive Branch that "the imposition of new or increased tariff duties on imports [was] authorized by the language adopted."[23] Fully aware that the Executive Branch then, as in 1955, understood the provision as authorizing the imposition of monetary exactions, the Committee did not recommend any change in its wording to confine more narrowly the bounds of its authorization. On the contrary, the Committee in its report indicated with approval its own, understanding that the statute provided "those best able to judge national security needs [with] a way of taking *whatever action is needed* to avoid a threat to the national security through imports." H.R. Rep. No. 1761, 85th Cong., 2d Sess., 13 (1958).

While Congress in 1958 made several procedural changes in the statute and established criteria to guide the President's determination as to whether action under the provision might be necessary, it added no limitations with respect to the type of action that the President was authorized to take.[24] Pub. L. No. 85-686, § 8, 72 Stat. 678. The 1958 re-enactment, like the 1955 provision, authorized the President under appropriate conditions to "take such action" "as he deems necessary to adjust imports. . . ." 72 Stat. 678.

When the national security provision next came up for re-examination, it was re-enacted without material change as § 232(b) of the Trade Expansion Act of 1962. In its analysis the Court of Appeals placed great emphasis on the fact that in the course of Congress' deliberations the Senate passed and the conference committee deleted, H.R. Conf. Rep. No. 2518, 87th Cong., 2d Sess., 13 (1962), an amendment which provided:

> "Notwithstanding any other provision of law, the President may, when he finds it in the national interest, proclaim with respect to any article imported into the United States—(1) the increase of any existing duty on such article to such rates as he finds necessary; (2) the imposition of a duty on such article (if it is not otherwise subject to duty) at such rate as he finds necessary, and (3) the imposition of such other import restrictions as he finds necessary." 108 Cong. Rec. 19573 (1962).

The Court of Appeals inferred from the rejection of this amendment that Congress understood the then existing grant of authority to be limited to the imposition of quotas. According to the court, the amendment would have "explicitly [given] the President the same authority he claims derives implicitly from § [232 (b)]" 518 F. 2d, at 1059, and Congress' refusal to enact the amendment was tantamount to a rejection of the Government's interpretation of the statute.

We disagree, however, with the Court of Appeals' assessment of the proposed amendment. The amendment was in reality far more than an articulation of the authority that the Government finds to be contained in § 232(b). Unlike § 232(b), the rejected proposal would not have required a prior investigation and findings by an executive department as a prerequisite to Presidential action. Moreover, the broad "national interest" language of the proposal, together with its lack of any standards for implementing that language, stands in stark contrast with § 232(b)'s narrower criterion of "national security" and § 232(c)'s articulation of standards to guide the invocation of the President's powers under § 232(b). In light of these clear differences between the rejected proposal and § 232(b), we decline to infer from the fact that the Senate amendment was proposed, or from the fact that it was rejected, that Congress felt that the President had no power to impose monetary exactions under § 232(b).

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[22] We are not unmindful that, as respondents point out, much of the congressional debate referred to the Byrd-Millikin amendment in the context of giving the President the power to impose import quotas. See, *e.g.*, 101 Cong. Rec. 5572 (1975) (remarks of Sen. Humphrey); *id.*, at 5582, 5584 (remarks of Sen. Douglas); *id.*, at 5593 (remarks of Sen. Monroney). But nowhere do the congressional debates reflect an understanding that under the amendment the President's authority was to be *limited* to the imposition of quotas. In light of this fact, we feel fortified in attaching substantial weight to the positive indications discussed above that the authority was not so limited.

[23] Foreign Trade Policy Compendium of Papers on United States Foreign Trade Policy Collected by the Staff for the Subcommittee on Foreign Trade Policy of the House Ways and Means Committee, 643 (1957).

[24] Indeed, while under the 1955 provision the President was authorized to act only on a finding that "quantities" of imports threatened to impair the national security, the 1958 provision also authorized Presidential action on a finding that an article is being imported "under such circumstances" as to threaten to impair the national security. Pub. L. No. 85-686, 72 Stat. 678. See pp. 12-13, *supra*.

Only a few months after President Nixon invoked the provision to initiate the import license fee system challenged here, Congress once again reenacted the Presidential authorization encompassed in § 232(b) without material change. Trade Act of 1974, Pub. L. No. 93–618, 88 Stat. 1993 (1974). Making no mention of the President's action, both the Senate Committee report and the conference report recited the language of the statute itself to reaffirm that under § 232(b) the President "may take such action, and for such time as he deems necessary to adjust imports so as to prevent impairment of the national security." H. R. Conf. Rep. No. 93–1644, 93d Cong., 2d Sess., 29 (1974); S. Rep. No. 93–1298, 93d Cong., 2d. Sess., 96–97 (1974). The congressional acquiescence in President Nixon's action manifested by the re-enactment of § 232(b) provides yet further corroboration that § 232(b) was understood and intended to authorize the imposition of monetary exactions as a means of adjusting imports.

Taken as a whole then, the legislative history of § 232(b) belies any suggestion that Congress, despite its use of broad language in the statute itself, intended to limit the President's authority to the imposition of quotas and to bar the President from imposing a license fee system like the one challenged here. To the contrary, the provision's original enactment, and its subsequent reenactment in 1958, 1962, and 1974 in the face of repeated expressions from Members of Congress and the Executive Branch as to their broad understanding of its language, all lead to the conclusion that § 232(b) does in fact authorize the actions of the President challenged here. Accordingly, the judgment of the Court of Appeals to the contrary cannot stand.

C. A final word is in order. Our holding today is a limited one. As respondents themselves acknowledge, a license fee as much as a quota has its initial and direct impact on imports, albeit on their price as opposed to their quantity. Brief for Respondents, at 26. As a consequence, our conclusion here, fully supported by the relevant legislative history, that the imposition of a license fee is authorized by § 232(b) in no way compels the further conclusion that *any* action the President might take, as long as it has even a remote impact on imports, is also so authorized.

The judgment of the Court of Appeals is reversed and this case is remanded to that court for proceedings consistent with this opinion. So ordered.

QUANTITATIVE OIL IMPORT CONTROLS

(Excerpt from "Energy Legislation in the 94th Congress," a report prepared by the Environment and Natural Resources Policy Division, CRS, for the Senate Committee on Interior and Insular Affairs. Committee Print. October 1976)

94th Congress
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COMMITTEE PRINT

ENERGY LEGISLATION IN THE 94TH CONGRESS

A Summary Report

Prepared by the

CONGRESSIONAL RESEARCH SERVICE

At the Request of

Henry M. Jackson, Chairman

COMMITTEE ON INTERIOR AND
INSULAR AFFAIRS
UNITED STATES SENATE

PURSUANT TO

S. Res. 45

A NATIONAL FUELS AND ENERGY
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NATIONAL FUELS AND ENERGY POLICY STUDY

(SENATE RESOLUTION 45, 92D CONGRESS)

This publication is printed for the use of Senators participating in the National Fuels and Energy Policy Study, authorized by Senate Resolution 45 of the 92d Congress.

Senate Resolution 45, introduced by Senators Jennings Randolph and Henry M. Jackson, was amended and agreed to by the Senate on May 3, 1971. The resolution authorized the Senate Committee on Interior and Insular Affairs and ex officio members of the Committees on Commerce and Public Works and the Joint Committee on Atomic Energy to make a comprehensive study of programs and policies required to meet national energy needs.

Subsequently, the Senate approved the addition of ex-officio members from the Committees on Aeronautical and Space Sciences, on Finance, on Foreign Relations, on Government Operations, and on Labor and Public Welfare.

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V. Reduce Dependence on Foreign Imports of Oil

During the 3 years since the Arab oil embargo in mid-October 1973, a consensus has been reached within Congress and the administration that the country's growing dependence on imports of foreign oil is undesirable, that it should be curbed and, hopefully, reduced.

This consensus on the broad objective, however, has not yet been matched with a concensus on means. The administration's position has been that oil imports can and should be reduced through imposition of import tariffs, fees, and/or excise taxes, coupled with removal of price controls on domestic oil and gas, relying on the higher prices to lower imports through lowered consumption. Higher prices would also serve, it is argued, to stimulate increased domestic production of not only oil and gas but alternative energy sources as well.

The Democratic position in general placed more reliance on quantitative controls, through various types of import quotas and other energy management measures. Decontrol of oil and gas prices is to be permitted, but only gradually and at a slower rate than the administration desired.

During the 94th Congress there was a great deal of legislative activity and debate on import tariffs and quantitative oil import controls.

During this period, while the debate over how to reduce dependence on imports escalated, so did oil imports: By the end of the first week in October 1976, foreign oil imports reached a level of 7,622,000 barrels per day (5,988,000 b/d in crude and 1,634,000 b/d in oil products). This was 1,695,000 b/d higher than in October 1975 and already exceeds the levels stipulated in the House-passed Ways and Means bill, H.R. 6860, of 6 million b/d for 1976 and 6.5 million b/d for 1977.

Furthermore, domestic production of crude oil declined during the same period, from 8,311,000 b/d during the first week of October 1975 to 8,040,000 b/d in the week of October 1976, creating additional pressures to increase imports.

The debate on limiting oil imports therefore is of prime significance.

A. OIL IMPORT TARIFFS AND OTHER FEES

Following up on the administration's comprehensive energy plan, formally announced January 15, 1975, and introduced as S. 594 and H.R. 2633 and H.R. 2650 on February 5, 1975, President Ford imposed a $1 a barrel tax on imported oil, effective February 1, to rise to $3 in two additional $1 increases scheduled for March 1 and April 1, 1975.

At the same time he stated that "I am prepared to use Presidential authority to limit imports, as necessary, to guarantee success" in reducing imports. Title IX of the administration bill, directed at insuring price stability should foreign prices fall, would provide specific authority to use tariffs, quotas, and variable fees to control imports as well as to establish a floor price for domestic oil.

Congress responded immediately with a bill, H.R. 1767, introduced in the House on January 20, 1975, to suspend for a 90-day period the authority of the President under section 232 of the Trade Expansion Act of 1962, or any other provision of law, to increase tariffs or to take any other import adjustment action with respect to petroleum or petroleum products and to negate any such action which may be taken by the President after January 15, 1975.

The bill passed the House by a vote of 309 to 114, February 5, and was approved by the Senate February 19, by a vote of 66 to 28.

It was vetoed by the President on March 5, 1975, but only after he announced that in the interests of accommodation and to provide additional time for congressional action he would postpone the additional $2 tariff on oil imports until May 1.

On April 30, he again announced a further delay in import fees until June 1 to give Congress further time to develop its alternatives. Subsequently, on May 27, 1975, after Congress had recessed without agreement on comprehensive legislation, the President announced the imposition of the next $1 fee on imported crude oil and $0.60 on imported refined products, effective June 1, 1975.

On July 30, 1975, the FEA Administrator announced that FEA was prepared to eliminate the 60-cents-per-barrel tariff on refined oil products imported into the United States. However it was apparent that this offer was contingent on congressional agreement to the administration's price decontrol plan and congressional disapproval of that plan, on the same day, left the outcome of the offer to drop the tariff in imported refined products in doubt.

Meanwhile, a vote to attempt to override the veto was postponed while intensive committee review of the Democratic alternative programs went forward in both the House and Senate.

The House included an ad valorem tariff in its first major composite energy bill, H.R. 6860, which passed the House on June 19, 1975, and was reported by the Senate Finance Committee on August 27, 1976, but not put to floor vote before adjournment.

The bill imposes a tariff on oil imports of 2 percent ad valorem for crude oil and 5 percent ad valorem for petroleum products. These are approximately the levels of the import license fees that were in effect in January 1975 under the national security provision of the Trade Expansion Act. The authority of the President to impose oil import tariffs or quotas under that act (except in the case of war) is terminated, but the President is given the authority to increase the oil import tariff to 10 percent ad valorem or $1 per barrel, whichever is higher. For a 2-year period, however, the tariff on residual and distillate fuel oil is limited to 5 percent.

These and other measures using import fees were overtaken and, for the time being, superseded with the signing of the Energy Policy and Conservation Act, Public Law 94–163.

In a statement and fact sheet isued when he signed the bill, on December 22, 1975, the President announced the removal of the $2 per barrel import fee, which was made effective as of the same day, and stated that while he believed the price decontrol provisions which were included might permit "imports to increase by approximately 150,000 barrels per day by the end of 1976, imports probably will be about 200,000 per day less after 3 years, due to future price increases allowed by the bill," and at the end of 40 months when price controls end entirely, should "reduce imports by about 3 million barrels per day."

(It is important to keep in mind that the administration's estimates of reductions in imports have, to date, been measured against an otherwise anticipated rapid rise, to 12 million barrels a day by 1985 if no new actions are taken.)

B. QUANTITATIVE OIL IMPORT CONTROLS

Two major omnibus alternative energy policy approaches were announced by members of the Democratic majority 6 weeks after the administration's program was announced. One entitled "The Congressional Program of Economic Recovery and Energy Sufficiency," was announced by the majority leaders of both House and Senate, February 27, 1975; and the other was prepared by eight task forces made up of the Democratic members of the House Ways and Means Committee, issued March 3, 1975.

The two proposals, although favoring quantitative controls as preferable to increased import tariffs, differed on how, when and to what degree such controls would be applied.

The most specific active legislative proposal mandating quantitative oil import controls was included in H.R. 6860, a clean bill reported from the Ways and Means Committee by the fairly close vote of 19 to 16, on May 15, 1975, after a marathon, almost nonstop series of hearings and open markup sessions, beginning March 3, 1975. The bill passed the House on June 19, 1975.

With quantitative import control provisions stronger than those included in H.R. 5005, originally introduced March 17, 1975, the proposed legislation would impose mandatory quotas on oil imports. These were set at 6 million barrels per day in 1975 and 1976, 6.5 million barrels per day in 1977, 6 million barrels per day in 1978, and 5.5 million barrels per day thereafter. These levels are lower than the level of imports prevailing prior to the oil embargo and, together with a civilian strategic reserve and a program for standby emergency conservation measures, would, it was believed, provide adequate protection against an oil embargo.

As described in the committee's report (H. Rept. 94–221):

> Your committee does not intend that these import quotas be an energy conservation measure in themselves. Rather, the levels of the quotas are designed to reflect the energy conservation and conversion measures elsewhere in the bill, and the purpose of the quotas is to make sure that all oil savings resulting from the conservation and conversion program are reflected in reduced imports. The President, therefore, is given the authority to vary the level of the quota. Because of the greater uncertainty about the level of demand and domestic supply farther into the future, the President is given more flexibility in later years. The bill gives the President the authority to vary the basic quota by up to one million barrels per day in 1975, 1976, and 1977, 1.5 million barrels per day in 1978 and 1979, and 2 million barrels per day in 1980 and thereafter. If the quotas are at all restrictive, to prevent oil importers from receiving excessive profits from the import licenses provided under the quota system and to allocate oil imports as efficiently as possible, import licenses are to be distributed through public auctions. Also, to ensure that users of imported fuel oil have time to convert to other energy sources, import restrictions for residual and distillate fuel oil are set at a minimum of 2 million barrels per day for the years 1975–1977 out of the overall quotas for those years.

The chairman of the Ways and Means Committee had intended to seek House passage before the Memorial Day recess, and floor debate had been scheduled for May 21 and 22, subject to clearance by the Rules Committee. The Democratic leadership decided on May 20 to postpone debate until after the recess, hoping to be able to consider the proposals jointly with the House Commerce Committee's complementary companion bill, H.R. 7014, not then reported from committee.

When it became clear that the House Commerce Committee would not be able to report H.R. 7014 in time for joint consideration, the House proceeded to consider the Ways and Means bill alone, in the general understanding that other complementary and supplementary measures were pending in other committees.

General debate began June 9, 1975, under a rule, H. Res. 505, which permitted consideration of the more than 100 pending amendments title by title.

The quantitative import quota provision came under attack almost immediately, with a recommendation that it be striken entirely from the bill. The motion was rejected by a vote of 185 ayes to 224 noes, on June 10, 1975, and title I was retained with a modification which increased the ceilings permitted for 1979 from 5.5 million barrels a day to 6 million barrels per day, and for 1980, from 5.5 million barrels per day to 6.5 million barrels per day. The adjustment was based primarily on the prediction that, even with positive action to bring about substantial savings in consumption and positive incentives to increase domestic production, total domestic oil production was likely to at best remain at present levels but could still continue to decline as old fields went out of production faster than new fields could be brought into flow. The vote approving the increase, on June 11, 1975, was 211 ayes to 200 noes and, at these levels, quantitative quotas were retained in the final bill which was approved on June 19, 1975, by 291 ayes to 130 noes.

However, as noted above, the Senate Finance Committee reported a version of the bill which omits the import quota provision.

C. IMPORT QUOTAS—A DUAL ROLE

Although the 94th Congress did not reach agreement on this important management tool, the debate has already produced a much more comprehensive awareness of its wider role in reshaping energy demand and stimulating new supplies. As stated many times in this report, the administration's energy policy has emphasized the central role of a pricing policy designed to increase the cost of oil and natural gas as a dual measure for both cutting back on consumption and encouraging increased production of domestic supplies.

During the course of the floor debate on H.R. 6860, a parallel alternative concept was put forward, namely, that quantitative limitations on petroleum imports would also serve a dual role, both to promote conservation of energy and to encourage increased domestic production of not only oil and natural gas but also alternative energy resources.

It should be noted that this rationale was a new phenomenon in the evolution of the Ways and Means energy proposals. As a number of opponents of the bill sharply pointed out, the committee report had downplayed the role of quotas as a direct constraint on consumption, arguing that its role would be rather to insure that petroleum savings otherwise achieved would be reflected in savings in imports.

However, this premise was promptly challenged by both opponents and proponents of the quantitative import limitation provision, early in the debate and even before the tax on gasoline was removed from the bill:

> Mr. KETCHUM. I find it absolutely amazing that the committee majority continues to believe that quotas on imports are not going to produce a major crunch. Just listen to this language from the committee report:
>
> "Your committee does not intend that these import quotas be an energy conservation measure in themselves * * * a comprehensive program of quota restrictions is necessary to be sure that the conservation achieved by other provisions in the bill will result in a reduction in foreign imports rather than a reduction in domestic production."
>
> This premise is so false that it defies comprehension. Domestic production is declining and this pious hope will not stem the decline. On the contrary, other actions already taken by Congress, such as the repeal of the depletion allowance, and actions being contemplated such as a windfall profits tax insure a drop in domestic energy activity. The FEA estimates that, at best, there would be a 1 million barrel a day increase in petroleum production, if a massive development program were underway and oil sold at $11 a barrel. These are optimistic assumptions by anyone's standards. At the same time, assuming a 4-percent increase in demand a year, we will need between 7 and 9 million barrels a day of imported oil, figures well above the 6 million barrel a day quota. So how in the name of heaven can the supporters of this bill say that the quotas would not have a tremendous impact?[1]

* * * * * * *

> Mr. CONABLE. This quota supposedly has enough flexibility so that it will not bite, but if the gasoline tax is eliminated I do not think there is any doubt that the quota, as a quantitative limitation would in fact come into play and cause serious problems in the administration of the resulting scarcity.[2]

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> Mr. OTTINGER. We have in the bill which is coming up from the Commerce Committee provided allocations, so that if import quotas create some shortfall and it may well do that at some time in the future, we will be able to manage that and the President will have the authority to make the necessary allocation.
>
> We have got to take some hard decisions in this House and any way we turn is hard. If the decision is to go to the price route, it means everybody is going to pay huge increases in price for everything in our economy. If we decide to do nothing to conserve, we are going to have this absolutely horrendous transfer of assets to the OPEC countries. Quotas and allocations with price controls is by far the best alternative.
>
> I think this is at the heart of the bill. Regardless of what people do on the gasoline tax, if we have a quota in place we will have a meaningful congressional energy policy.[3]

The Congressman who fought the hardest to strike all of title I, on oil import quotas, was the first to argue that its effect would in fact be so rapidly to drive up domestic oil production as to "drain America first":

> Mr. GIBBONS. Now, oil is a very precious commodity. If we call up the Federal Energy Agency and ask them how much oil there is in the United States within the 50 States, the safe 50, they will tell us there are about 4,000 days of oil left in this country.
>
> If we call up the U.S. Geological Survey and say, "How much oil is left in this country, oil we know is here and oil we hope is here and how long will that last at

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[1] Congressional Record, June 10, 1975, p. H5218.
[2] Ibid., p. H5231.
[3] Ibid., p. H5238.

the present rate of consumption?" They will tell us oil we know is here and oil we hope is here and oil we know is on the Outer Continental Shelf, all that oil will last for all of 35 years.

Now, how old will we be when that oil runs out and how old will our children and grandchildren be when that oil runs out? What kind of heritage will we be leaving for ourselves and what kind of heritage will we be leaving for our children and for our grandchildren? What kind of position are we puting the United States in as far as bargaining just down the road? What kind of position are we putting the United States in as far as national security is concerned?

Our answer to all those questions has got to be that we are putting them in the worst possible position that we could dream of. What worse position could we get ourselves in than to use up our most precious natural resources before and at a much more rapid rate than we should be exhausting it.

If we put on quotas, that is the only result that can happen. The only reason for quotas is to protect domestic production and to make domestic production run at its top rate, while the rest of the world goes on with its oil resources.[4]

Proponents agreed that the effect of quotas firmly applied, would indeed provide a "bite" and a "crunch" but pointed out that, with or without quotas, oil as a finite resource was being depleted in the United States and throughout the world, that quotas served notice both to OPEC and to ourselves that the United States must move swiftly to develop not just remaining oil but also all available sources alternative to oil.

Mr. BELL. Mr. Chaiman, I just wanted to point out something else which I think has not been mentioned. When we talk about draining the resources of our country, we also should be considering the fact that we are encouraging other oil companies in this country to go out and explore. By this proposal we are encouraging this, which is also a very important facet of this program it seems to me.[5]

* * * * * * *

Mr. CORMAN. If we must cut back on those imports or, at least, hold them where they are, then clearly the sensible way to do it is through an import quota. It will be the incentive for investing in domestic exploration and production. If we do it merely by price, we will further bloat the profits of the oil companies, and we will leave totally within their discretion where exploration money is spent.[6]

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Mr. KOCH. The only way we could find a feasible way of facing up to the problem is laying out the numbers of barrels, as we have here. Oil is a finite commodity. The gentleman says we have a glut of oil, but the world will be out of oil in 20 or 30 or 35 years. There is no long-range glut of oil, and in terms of history that is a very short time.

This country peaked out in production 5 years ago, and production has gone down each year since. The best possible way of developing alternative sources and assuring that there will be a market is to establish this kind of quota system, This is the heart of the bill.[7]

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Mr. GREEN. Every country in the world is running out of oil, and we have to find alternate sources of energy. That is one of the things this bill has tried to do, to stop being energy hogs, to serve notice that we intend to discipline ourselves. We have very carefully tailored this quota, and we have time in the future, if we have made a mistake to correct it.

The quota that would be in effect this year will not be reached and if it were and we were in some kind of a tight bind and needed oil, we have given the President an additional 1 million barrels a day for the next 2 years, discretionary authority. By balance, I think we have built in the kind of flexibility we need to begin to come to grips with this problem. American oil is drying up with or

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[4] Ibid., p. H5230.
[5] Ibid., p. H5231.
[6] Ibid., p. H5233.
[7] Ibid., p. H5235.

> without a quota. We cannot afford the dependence today. We must develop our own sources.[8] . . .
>
> The fact of the matter is that we are going to run out of oil at some point, and unless we begin to develop alternate sources of energy in this country, we are in trouble.
>
> Let us say it is 35 years, 13 years, or 42 years, or let us say it is 112 years. The fact of the matter is that we are going to run out of oil in this country, and we cannot, in the meantime, continue to be dependent and be placed in a position where the OPEC countries can strangle the United States of America. Unless we begin to put a quota on as to how much we are going to take, and unless we begin to develop alternate sources of energy in this country, we can quibble as to whether it is 35 years, 13 years, or 50 years, but we have to get down to doing the job that is necessary.[9]

At the end of the 2 weeks of hard fought floor debate, as the House moved toward the final showdown vote on June 19, 1975, the Chairman of the Ways and Means Committee summed up the message that was intended to be communicated through the measure and through the then still pending critical vote, which shortly afterward passed by a vote of 291 yeas to 130 nays.

> Mr. Ullman. Mr. Chairman, we are about to conclude a long and tedious debate on the subject of energy.
>
> We know better now than we did in the beginning that there are no easy answers. There will be, I understand, a recommittal motion; but I would like to say to my colleagues that a recommittal has to be a dead end. There is no way we can go back to the committee and take a new turn. . . .
>
> We begin by telling the OPEC countries and the world that we are putting a limit on the amount of oil we import. From now on we are not going to import oil without limit. We are telling the oil-producing countries that there will no longer be an unlimited flow of petroleum into this country from abroad.[10] We are telling industry and utilities, through our excise tax provisions, that they simply must begin the job of converting to coal and nuclear energy. We are telling the automobile industry that they simply have to start building more efficient automobiles in this country.
>
> We have credits here for the average citizen with respect to home insulation to conserve heat, which is very important.
>
> We have tax incentives that I think are very important in developing the flow of capital into vital areas which will produce alternative energy sources.
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> We have a trust fund that goes specifically to developing alternative energy sources in a meaningful way. This also is very important . . .
>
> Mr. Chairman, the way that legislation is passed in Congress is that we build a framework, we build a base and this is a base. We build over it in subsequent legislation. That is the way it ought to be with energy policy.
>
> Soon to come along will be the energy bill from the Committee on Interstate and Foreign Commerce on which they have jurisdiction, and these two measures will work together. Then after that we will have the bill brought out by the gentleman from Washington (Mr. McCormack) on NASA and atomic energy. That is another ingredient added on to what we now have and will soon have. Together, they will all make up our energy policy.[11]

Some of these controversial portions of the new national energy policy await further Congressional action, but the legislative process just described is now well under way. With the enactment of the two major multifunction energy acts and related laws, the framework laid out in the early composite plans has been substantially converted to a base on which additional energy legislation and new policy can continue to be built.

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[8] Ibid., p. H5230.

[9] Ibid., p. H5236.

[10] Mr. Ullman spoke extemporaneously on the floor and was misquoted in one respect by the recorder; he used the word "companies" not "countries" in the second sentence. As phrased in the written text of his remarks, issued at the end of the debate, this paragraph reads: "The energy bill passed today is a message to the world that we are not going to import unlimited foreign oil. It's a message to the oil companies that they can't count on mounting supplies of OPEC oil for their refineries—that they must restructure their production. We are signaling industry and electric utilities that a massive shift away from oil toward other sources of energy must begin. And the energy bill includes a clear order to produce cars that don't waste so much gasoline."

[11] Congressional Record, June 19, 1975, pp. H5743–45.

These and other still controversial issues await further Congressional action, but the legislative process just described is now well under way.

D. PRODUCTION INCENTIVES AND ASSISTANCE

INDUSTRIAL MOBILIZATION AND PROCUREMENT

(Excerpt from "The Sinews of War: Army Logistics 1775–1953", by James A. Huston, Office of the Chief of Military History, United States Army, Washington, D.C., 1966.)

From the moment the United States became actively involved in World War II it was clear that the country must mobilize for total war. To the question "how much?" the answer already was evident: "as much as possible of everything." But this still left crucial questions to be answered. How much was possible? What was the proper "mix?" Should facilities and resources be devoted to motor trucks or airplanes? Should there be more small arms or more artillery? Were landing craft more essential than railway cars? What possible basis was there for knowing what would be needed one to two years hence when current production plans would be in terms of military hardware?

Planners and responsible leaders during World War II took small advantage of the example and experience of the country's mobilization for World War I, but went about making many of the same mistakes and suffering the same frustrations as had their predecessors. They reassured themselves that "this war is different," and excused their mistakes and frustrations with the observation that no one could foretell what form the war would take. Indeed, no one could foresee the future in any detail; but neither could the future be left to chance and the enemy. The war could, at least to a degree, be shaped to a desired form, depending on the decisions made for conducting it, which, in their turn, must depend on prevailing strategic concepts, estimates of relative capabilities, enemy actions, and, above all, imagination.

Perhaps the greatest failure of all was the failure of Germany to read the lessons of 1918 and 1919 on the capacity of the United States to produce. Early in 1942, when war production was just beginning its expansion, General Somervell said:

> The road ahead is dim with the dust of battles still unfought. How long that road is, no one can know. But it is shorter than it would have been had not our enemies misjudged us and themselves. For, when Hitler put his war on wheels he ran it straight down our alley. When he hitched his chariot to an internal combustion engine, he opened up a new battle front—a front that we know well. It's called Detroit.[1]

INDUSTRIAL EXPANSION

Following its practice in all wars, the United States on the eve of World War II mobilized troops before weapons and equipment could possibly be available for them. Although in the spring of 1940 the United States was the leading industrial power of the world with tremendous potential for expansion, it was far down the scale when it came to facilities for turning out munitions of war. There was neither the powder on hand nor the facilities to produce it to provide one day's supply for the force the United States would have overseas within three years. Soldiers on maneuvers in 1940 and 1941 often had to be content to use trucks to simulate tanks, and to carry sticks to represent guns and mortars. Lack of production facilities for military equipment made evident by orders from the Western Allies, lend-lease requirements, and the needs of partial mobilization, became critical with Pearl Harbor and total mobilization when more emphasis came to be placed where it probably should have been placed at first: on industrial mobilization as the key to rapid military mobilization. It became clear that facilities would have to be expanded in every possible way—by conversion of existing civilian plants to war production, by expansion of the government's own arsenals, by construction of new facilities, and by encouraging expansion and new construction on the part of private industry and by combinations of private and government undertakings.

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[1] Quoted in Automobile Manufacturers Association, *Freedom's Arsenal* (Detroit: American Automobile Manufacturers Association, 1950), p. v.

The greatest boon to privately financed expansion of facilities for the production of essential war goods was the tax amortization law which permitted a deduction from taxable income of 20 percent a year of the cost of building or acquiring facilities for national defense purposes. This was in lieu of the normal depreciation allowance of 5 to 10 percent a year. Thus complete amortization of new facilities could be accomplished in five years, and if the national emergency or the need for the plant should end before that time, complete amortization would be allowed for the shorter period. Coupled with higher rates on corporate income taxes and an excess profits tax adopted about the same time, the amortization law proved to be a powerful incentive for expansion, but could not alone possibly provide all the facilities that would be needed. More direct government action was necessary.

The first approach to government financing of industrial expansion took the form of Emergency Plant Facilities (EPF) contracts. In general these provided for government reimbursement, by monthly payments over a five-year period, of the cost of conversion or construction. Companies arranged for financing through banks or other private sources and made their own construction contracts. The contractor held title to the facility until full reimbursement had been received, when it reverted to the government, but he held an option to buy at cost less depreciation. Difficulties in satisfying the banks, the expense to the War Department to hold funds equal to the whole amount due on these facilities and still pay interest of 2½ to 4 percent, and problems of arriving at depreciation and meeting tax requirements led to the early obsolescence of this type of contract. More favorable arrangements soon were available under Defense Plant Corporation contracts. Set up by the Reconstruction Finance Corporation in August 1940, the Defense Plant Corporation, after a determination of need by the Army or other agency, would enter into a contract with the private firm to provide it with the funds needed for site acquisition and construction. The Defense Plant Corporation retained title to the property, and construction contracts of the lessee remained subject to its approval. The lessee paid a nominal rental (perhaps a dollar a year), depreciation rental, or full rental, depending on the nature of the items produced. At the end of the emergency the lessee had the option to buy the facility at cost less rental payments, or cost less depreciation, whichever was higher. Interest on the loan was at the rate of 1½ percent. Over 80 percent of the $3 billion which the Defense Plant Corporation advanced went for expanding facilities for the production of aircraft and related items.

Most important were the facilities constructed with the War Department's own funds. There was some expansion at the arsenals and depots operated by the War Department, but for the most part the new War Department-owned facilities were built by private construction companies under cost-plus-a-fixed-fee contracts, and operated by private contractors for a management fee. Generally referred to as government-owned, contractor-operated plants, they were mostly ordnance facilities for the production of powder, bombs, shells, and chemicals. The largest, the Sunflower Ordnance Works at Lawrence, Kansas, represented a capital outlay of more than $180,000,000. This program also began with rearmament in 1940, gained impetus with the passage of the Lend-Lease Act in March 1941, and was redoubled after Pearl Harbor. The total investment in new War Department facilities through September 1945 was over $4.3 billion. These were mostly facilities having little or no use for commercial production, and, since they remained in the hands of the War Department, they could be retained in reserve after the war.

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PROCUREMENT POLICIES

Except as the most common denominator for expressing calls upon manpower and resources, financial problems were secondary for wartime procurement. While more elaborate accounting procedures were necessary to keep track of the huge sums involved in the fourteenfold increase in Army expenditures during the war, Army budgets now were targets rather than ceilings. In fact, $60 billion (for all agencies) of unused appropriations remained on the books at the end of the war. Nevertheless, firmer central control over Army finances came with the appointment of a fiscal director in the Army Service Forces, and control of funds became a principal means for controlling and coordinating policies of the Army services.

Contracts and Pricing

Government contracting and purchasing policies always have been subject to a good deal of red tape not only in protecting public expenditures, but also in supporting certain special interests or secondary economic policies. In addition to legislation of long standing that required formal advertising for competitive bids and awards to the lowest responsible bidder, other laws in effect at the time of Pearl Harbor included those which required the use of only domestically produced materials, prohibited payroll deductions, forbade the employment of women under eighteen years of age on government orders, limited workers under goverment contracts to an eight-hour day, prohibited advance payments to government contractors, and established various labor standards. Whether calculated to protect the public purse or to protect special interests, these laws and regulations set up such an imposing bundle of red tape that many firms preferred to avoid all government contracts rather than attempt to modify their policies and organizations to conform to government restrictions. The result was unfortunate even in peacetime. In wartime it was intolerable. After delaying the rearmament program during the 1940–41 defense period to a considerable extent, most of these restrictions were swept away shortly after Pearl Harbor, though Army procurement agencies never were permitted to lose sight of the desirability of economy in all their transactions.

The pressure for speed which came with full involvement in the war brought a growing preference for contracting by negotiation rather than through formal advertising, until early in 1942 when the War Production Board abandoned the latter method altogether. For a time the new freedom in contracting imposed new restrictions as headquarters and agencies at various levels introduced their own restrictions to insure themselves against charges of favoritism, collusion, or improper awards of contracts. Insofar as practical, the principle of competition remained in the practice of soliciting informal bids from as many responsible and qualified suppliers as possible, and then making awards to the lowest bidders. But speed and capacity to perform were essential. In the interest of effecting as efficient an industrial mobilization as possible, the policy was to place contracts involving difficult problems with those firms best equipped to handle them. In these cases invitations to bid went to firms needing to add the least machinery and equipment in order to fill the orders. Less complicated tasks were reserved where possible for smaller concerns.

There was a strong trend toward decentralization of procurement responsibilities and actual negotiation of contract. Chiefs of the technical services were authorized to award contracts involving expenditures of up to $5 million without reference to higher authority, and they in turn could further delegate this authority. This they did in varying degrees. The Quartermaster General, for instance, went all the way, and extended full authority to Quartermaster field procurement officers to enter into agreements up to the $5 million limit. The Chief of Transportation, on the other hand, centered all responsibility for negotiating contracts for major items in his procurement division, while supply officers in the transportation zones and at the ports of embarkation purchased secondary items and administered all the contracts placed in their respective areas.

Depending upon the nature of the items and the circumstances, contracts during World War II generally were either of the cost-plus-a-fixed-fee type or the fixed-price—whether lump sum or unit price—type. The cost-plus-a-percentage-of-cost contract that had been the subject of much investigation and criticism after World War I was outlawed from the beginning. Soon committees of both houses of Congress were reporting widespread abuses under the cost-plus-a-fixed-fee contracts, and were recommending that they too be abolished.

The outlawing of the cost-plus-a-percentage-of-cost contract may have been an instance where apparent logic triumphed over facts. There had indeed been extravagance and abuse of these contracts during World War I, but because at first glance it seemed logical that nothing else could be expected under an arrangement where a contractor's profit went up in proportion to his costs, the relative disadvantages of other forms of contracts tended to be overlooked. The form of cost-plus contract in most general use during World War I carried a sliding scale and a maximum fee. Now, by outlawing this type of contract in favor of the cost-plus-a-fixed-fee, the maximum fee was likely to become the fixed fee, without the benefit of a lower sliding scale based upon percentage of cost.

Again, logic favored a fixed-price agreement over any kind of a cost reimbursable arrangement, for only then was it possible to be sure what the ultimate cost to the government was going to be. But this too had serious drawbacks. Bidders felt it necessary to allow for every possible contingency in addition to a high profit in arriving at a fixed-price proposal. Actually, the ratio of profit to cost was far greater in the fixed-price than in the cost-plus-a-fixed-fee contracts; moreover, the costs were not necessarily less. In arriving at his price the bidder had to allow for all conceivable costs, and then he was tempted to use inferior materials and less-qualified workers, and to take undesirable shortcuts in filling the contract. When it came to research and development contracts, or the manufacture of new items for which there was no production experience, bidders were unlikely to accept at all unless there was some guarantee for covering costs which no one at the moment could forecast accurately. But by 1945 Under Secretary of War Patterson felt that there had been enough cost experience to permit converting all cost-plus contracts to fixed-price types. Hostilities ended before this program could be completed, but it represented the ultimate in a trend which had been operating from the early months of the war.

Probably the most difficult general problem in procurement was arriving at accurate cost estimates and settling on reasonable prices. Convinced that it could not be done satisfactorily in advance, the War Department in March 1942 issued regulations providing for the redetermination of prices according to a formula and ceiling applied after preliminary and trial runs of production and for revision of prices, either upward or downward, after 20 to 40 percent of a contract had been completed. The next month Congress passed the Renegotiation Act. As amended in October of that year, the act made it mandatory to include a renegotiation clause in all contracts with firms having renegotiable sales of over $100,000 in a fiscal year, and excepting contracts in the primary extracting industries such as mining and timber. The Secretary had discretionary power to exempt certain other contracts, and to rule that renegotiation would not apply to portions of certain contracts during certain periods of time. This allowed a measure of flexibility in offering incentives by sharing cost-savings with contractors, and by assuring them, after renegotiation, of firm forward prices not subject to further renegotiation. The Renegotiation Act of 1943 (approved in February 1944) extended the blanket exemption to $500,000.

At first the assumption had been that renegotiation would apply only to fixed-price contracts, but soon it became clear that excessive profits also were being made on cost-plus-a-fixed-fee contracts, and they too came under the scrutiny of the War Department Price Adjustment Board. Renegotiation did not apply so much to construction contracts as to supply contracts. For the latter a procedure had evolved whereby cost-plus-a-fixed-fee was set on a unit basis, so that while the margin of profit might be small per unit, large volume and the reduction in costs with production experience frequently led to an accumulation of profits that were high indeed. Yet recovery of excessive payments made under this type of contract was small compared to the amounts under fixed-price contracts. All together the War Department recaptured nearly $7.5 billion through the renegotiation of contracts, and the Navy and other government agencies recaptured about $3.5 billion. While not insignificant, these amounts are not very large in comparison with the total military procurement outlay of $300 billion for the war; in any event, excess profits taxes would have returned $7 billion to $8 billion of the total recovered. The real purpose of the renegotiation policy was not so much to recover excess profits as to prevent them. To the extent that it resulted in closer pricing and inflation control, the policy promoted efficiency in the use of resources, and, together with other measures taken for those purposes, renegotiation had a high degree of success in its main purpose.

The greatest weaknesses in the renegotiation laws undoubtedly were in the exemptions of raw materials and agricultural products and of construction contracts based on competitive bidding, as well as the blanket exemption of all firms having less than $500,000 in renegotiable sales in a year and certain permissive exemptions. All these exemptions opened the way for special consideration for special interests, while it was doubtful whether any of the general exemptions were justified either on moral or economic grounds. Far from relieving the administrative burden, they added to it.

One of the most significant developments in procurement pricing during World War II came with the adoption of a policy of progressive pricing. Although public emphasis tended to center on excess profits as the main object of concern, these profits represented but a small fraction of the total prices. Reduction in costs represented more efficient use of resources. This was the main object of the Army's consistent philosophy of "closing pricing." The trouble was that even when original prices could be set close to cost, the results of experience as evidenced in increased efficiency and added volume could widen the gap between cost and profit—or costs as calculated might remain close to the price when they could have been reduced by more careful management. This actually amounted to a hidden inflation. In adopting progressive pricing, Army procurement agencies gave up the idea that there was a single ideal price for any particular contract, and adopted the idea of reviewing prices from time to time while a contract was in effect. On the basis of experience of the appearance of unforeseen developments, prices then might be adjusted either upward or downward, so that three or four different prices might be in effect during the term of the contract. It was assumed, too, that the contractor might retain a higher profit margin when he reduced his costs, and he might be guaranteed retention of this gain by exemption from negotiation. Both contractors and contracting officers were hesitant about using progressive pricing for some time, the former because they wanted to retain the higher prices as protection against all contingencies, and the latter because they feared that the higher margins of profit that were likely to be granted might appear unreasonable, or the result of collusion, to some future investigating committee. By 1944, however, the practice had come into fairly general use, and it probably made a real contribution to reduction in costs and increased efficiency.

A further consideration in price redetermination and renegotiation was the over-all position of the firm in question. It soon became evident that in cases of companies having a large number of war contracts, a far more accurate picture of costs and profits could be seen if all the company's government business were examined together rather than individually, contract by contract. As developed by the summer of 1944, the company pricing program involved the appointment of pricing teams to examine the situation of selected companies and to analyze the extent and causes of high prices, high costs, and excessive profits. This made it possible to give special attention to common costs among several contracts, differentials in civilian and military busness, total volume, and subcontract prices. Earlier, subcontract prices had had little scrutiny, and unduly high prices for components simply were passed on, usually with a mark-up, to the government. Some of the most notable examples of extravagent profits were likely to be here. When subcontract prices were found to be a major factor in a price contractor's price position, the War Department entered into direct negotiations with the company's subcontractors with a view to recovering excessive profits and reducing prices; these savings would be passed to the prime contractor who in turn would be persuaded to pass the saving along to the government. The effectiveness of the company-pricing program for the eighteen months it was in effect is difficult to assess. In particular cases it demonstrated great merit, and the fact that 100 major contractors held two-thirds of the War Department's contracts as well as a large number of subcontracts indicates the coverage that the selection of this number of companies for price review could mean.

The Civilian Economy

Further problems for Army procurement agencies rose out of efforts to control inflation and hold the price line in the civilian economy. As contemplated in the Industrial Mobilization Plan, the Office of Price Administration (OPA) was established for this purpose. Immediately the question had to be met as to the extent the regulations of this agency would extend to military goods. Both the Secretary of the Navy and the Secretary of War appealed to Congress as well as to the President to permit the military services to make their own determination as to when exemptions from OPA price ceilings should be granted. The request was refused. The Secretaries then turned to negotiations with OPA, and subsequently arrived at an agreement whereby strictly military goods—comprising about two-thirds of military procurements—should be exempted from OPA regulations. There remained an important area of overlap, particularly in items of food and clothing, where military procurement had to be based on OPA price ceilings. As for rationed items, the OPA generally agreed to allow the Army unlimited rationing accounts in return for the Quartermaster General's undertaking to establish limits for their use. In many cases Army posts set up their own boards for issuing coupons to soldiers for the purchase of gasoline, tires, and other items for their private use.

Some points of controversy developed when OPA on occasion sought to extend its authority over strictly military items, and the red tape and delays involved in attempts to obtain relief from price ceilings on items the Army considered essential were irritating; however, close liaison between the War Department and OPA, and a general appreciation of the problems each faced, helped to maintain a healthy attitude of cooperation. On the whole OPA's remarkable success in resisting the heavy inflationary pressures of wartime was of great benefit to Army procurement. The stabilization of prices not only permitted vast savings, but encouraged conditions for negotiation of firm prices in military procurement. The success of the Army's own battle against high prices was suggested by the publication of quarterly indexes which showed a continuous decline in unit prices, for all except quartermaster items which were largely civilian-type goods, from 1942 to the end of the war.

Small Business

In the natural course of attempting to mobilize rapidly, and of placing orders where there was greatest confidence in obtaining large-scale production quickly, Army contracts tended to be concentrated with a relatively few large firms. In the early stages of mobilization it hardly could have been otherwise. But this brought the inevitable complaints from smaller firms which, without war contracts, found it increasingly difficult to obtain raw materials, and thus to remain in business at all. Actually, the picture of distress was exaggerated, for a large number of small plants already were busy with government contracts, subcontracts, or essential civilian orders. Nevertheless, there was a general feeling that at a time when all available resources were needed in the war effort small business should not be allowed to decline. If the main purpose of Congress in passing the Small Business Act in 1942 was relief for small firms, it paralleled a purpose of the Army to broaden the industrial production base. The act assigned various duties to the chairman of the War Production Board which he in turn delegated to a Smaller War Plants Division. This division worked closely with the Smaller War Plants Corporation which was established to make loans or advances to small concerns; to acquire and lease land, equipment, and materials; and to act as a prime contractor for war goods which then would be filled by subcontracting. The Smaller War Plants Division of the War Production Board was to survey production capabilities among small plants, and it might even certify certain small companies to be capable of filling certain contracts, in which case it was incumbent upon the procurement agency to award the contract to the company so designated. While the general pressure for mobilizing smaller plants probably benefited the economic mobilization, some of the specific measures were fraught with dangers. In practice the Smaller War Plants Division preferred to "designate" rather than "certify" plants, and then leave it to the discretion of the Army as to whether a plant could perform on a contract. As for the provision that the Smaller War Plants Corporation could act as prime contractor in organizing pools of subcontractors, this practice quickly fell into disuse and was of little significance, although its framers had considered it to be the heart of the act.

On the whole, mobilization of small plants—those having fewer than 500 employees—probably could not have been accomplished much sooner even had the Small Business Act been passed sooner, though the extent to which such facilities finally were used in military production probably was considerably greater than it would have been without the act. From 1943 to 1945 the share of the dollar value of War Department contracts going to small business rose from 12.6 percent to 27.4 percent. In addition, these firms received a growing share of subcontracts under the prime contracts of larger companies.

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SUMMARY

Several outstanding features contributed to a total productive achievement during World War II that could not have been imagined previously. Industrial mobilization and procurement were marked by swift conversion of industry to a wartime basis and expansion of both government and private facilities for wartime production, as well as the fearless acceptance of requirements to accomplish what had to be done. The policy for close-pricing in procurement contracts helped to reduce costs and increase efficiency. Controls, such as the Controlled Materials Plan, inaugurated to reduce competition for materials and facilities and thus eliminate bottlenecks in machine tool production and critical raw materials, greatly expedited both industrial mobilization and military procurement.

During the war years American industry produced, for the Navy as well as the Army, 40 percent of the world production of munitions, a fact that figured greatly in the Allied victory. Total War Department expenditures for the period from 1 July 1940 to 31 August 1945 were $167.4 billion, or 55 percent of all national defense expenditures, and almost 50 percent of the total federal budget for that period. Great as the achievement was, it might have been greater, and the job might have been done more swiftly if better use had been made of previous experience. Whether it would be surpassed in the future would depend on necessity and on the extent to which this experience might be applied.

EXAMPLES OF GOVERNMENTAL FINANCING FOR PETROLEUM RELATED PRODUCTS AND FACILITIES DURING WORLD WAR II

(Excerpts from Appendix 6, of "A History of the U.S. Petroleum Administration for War, 1941–45", prepared under the direction and editorship of John W. Frey and H. Chandler Ide, U.S. GPO, Washington 1946.)

Governmental Financing

GOVERNMENT EXPENDITURES RELATING TO PETROLEUM IN WHICH PAW HAD RESPONSIBILITY

In general, governmental financing with which PAW was concerned may be divided into three types: (1) Programs to defray losses involved in undertaking operations for the production of additional quantities of aviation gasoline; (2) programs to defray abnormal transportation costs arising out of war induced dislocations or adjustments in the movement of storage of petroleum and its products; and (3) programs to encourage the construction of facilities required to produce, refine, and transport petroleum and its products.

It is the purpose of this appendix to outline briefly the programs in which PAW participated to any major extent, to describe the purpose and scope of those programs, and to estimate upon the basis of figures available as of June 30, 1946, the amount of money involved in each program. The appendix is divided into three parts corresponding to the three general types of financing described in the preceding paragraph.

PART 1.—AVIATION GASOLINE REIMBURSEMENT PLAN

The problem.—The pressing demands of the war emergency required throughout that period resort to uneconomic and extraordinary methods of operation in order to supply the necessary minimum requirements of aviation fuels. These operations—the extensive planned blending program, frequent changes in product specifications, certain uneconomic and extraordinary capital adjustments—could be undertaken only through a program under which the high costs involved could be compensated for through direct Government assistance.

Because of the nature of the operations required it was not feasible in all cases to assure such compensation through price adjustments, and the negotiated contract prices under which the Reconstruction Finance Corporation and its subsidiaries purchased products for the armed forces[1] did not and could not take into account all of the extraordinary and high cost refinery operating adjustments required to meet the exigencies of the war. Accordingly, it was necessary to provide assistance through direct reimbursement to refiners for extraordinary expenses, which unreimbursed would have resulted in substantial financial losses.

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[1] See Four Party Purchase Agreement, infra, p. 361.

Such provision was made through the so-called Aviation Gasoline Reimbursement Plan, an agreement initiated by PAW and entered into by it as of July 24, 1942, with the War and Navy Departments, and the Defense Supplies Corporation. The agreement was entitled "Memorandum of Understanding on Plan to Reimburse Manufacturers of 91 Octane and Higher Aviation Gasoline for Losses Incurred in Following Office of Petroleum Coordinator Recommendations."

Under the agreement, the Defense Supplies Corporation agreed to reimburse manufacturers of 91 octane and higher aviation gasoline for such extraordinary costs and losses as were incurred by refiners at the request and with the approval of PAW. The Army and Navy would in turn reimburse the Defense Supplies Corporation for such costs in amounts proportionate to products delivered to the Army, Navy, and Lend-Lease.

Procedure and types of claims.—In addition to reimbursement for the extraordinary costs incident to the planned blending program and other operating adjustments required for maximum aviation gasoline production, certain allowances were made for financial losses incurred in making certain extraordinary capital expenditures in highly unusual situations in which no other mechanism could have been satisfactory. Such expenditures were of two types: (1) Expenditures covering the construction of C–S (cumene substitute) blending facilities; and (2) expenditures relating to the handling of other aviation gasoline components under the planned blending program. Where reimbursement was allowed for capital expenditures, it was limited to actual capital losses; in fact all reimbursement claims, except those involved in extraordinary construction expense program, covered only actual out-of-pocket losses. In respect to claims for extraordinary expenses regardless of type, several procedures for submission were established to fit the varying operating conditions under which losses might arise.[2] In order that claims might be recovered, the approval of PAW was required prior to the payment by RFC or its subsidiaries.

As originally devised, the plan applied to operations through December 31, 1942. After that date it was subject to cancellation upon 30 days' notice to the industry. It was administered by PAW and the Defense Supplies Corporation, assisted during the latter part of the war by a so-called Aviation Gasoline Reimbursement Plan Committee, headed by PAW, on which were representatives of the DSC, the Army, and Navy. The committee met monthly and was of material assistance in the solution of problems incident to operations under the reimbursement plan.

The first claims under the reimbursement plan were submitted to the Refining Division late in 1942, but no large volume of such claims was received until the latter part of 1943. Then it became necessary to set up a group in the Economics Section of the Refining Division to administer the claims. This particular group was primarily involved in the final settlement of the claim as an entirety. The responsibilities for various portions of the claim were distributed throughout the Refining Division.

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[2] Provision was made for adjustment of losses under contracts originally negotiated pursuant to the Four Party Purchase Agreement.

At various times during the war emergency the Refining Division prepared and submitted to the industry, advisory memoranda to assist and facilitate preparation of claims. These memoranda offered a procedure for preparing claims, suggested statement forms, and presented explanatory notes to facilitate use of the forms.

Modifications.—On June 3, 1943, a supplemental agreement, initiated by PAW, was entered into by the four signatories to the reimbursement plan. Its purpose was to accelerate and simplify reimbursement payments. It provided for partial payment of claims upon written recommendation of the Petroleum Administration for War, pending complete processing and final approval. Part payment could not exceed 75 percent of the total amount of the claim.

While the above supplemental agreement provided for making partial payments to refiners for their losses, it did not permit such reimbursement until refiners had submitted final claims for such expenditures to the Petroleum Administration. Since the preparation of final claims was a time-consuming process, it seemed desirable to amend the reimbursement plan so as to permit part payment in advance of such filing. This was the principal feature of the Amendment signed by the War and Navy Departments, DSC, and PAW on April 23, 1944. In May, the Defense Supplies Corporation issued regulation No. 1 which, in addition to a procedure for reimbursement, set forth terms and conditions necessary to assure protection to the Government in the event that a final claim was not duly certified, filed, and approved in an amount at least equal to the payments made on such preliminary claims. On July 31, regulation No. 1 was amended to include further procedures and was reissued as regulation No. 6.

The War and Navy Departments, DSC, and PAW believed it necessary to the successful prosecution of the war to continue the reimbursement plan and to effect—without altering its basic features—certain clarifications and changes. Accordingly, on July 1, 1944, the four parties signed a new agreement, effective through June 30, 1945, which superseded the previous arrangements pertaining to the reimbursement plan. Its provisions were subject to modification or cancellation on 30 days' notice by the Government to the refining industry.

One of the clarifications was a paragraph dealing with reimbursement of unusual capital losses which PAW found properly reimbursable and which had been incurred by refiners as the result of modifying, acquiring, and constructing special facilities for the manufacture of aviation gasoline. In January 1945, PAW issued instructions setting forth the procedure for preparing and submitting claims for recovery on these losses. A second major alteration incorporated in the July 1 agreement was the inclusion of the extraordinary construction expense program, the details of which are developed in part 3 of this appendix.

On June 30, 1945, the aviation gasoline reimbursement plan was extended through June 30, 1946. After VJ-day the date of expiration was modified. With the concurrence of the four signatories, the reimbursement plan was terminated, excluding claims based on operations concluded after September 30, 1945. However, in view of the Government's inability to lift blended product, and because of labor disputes, it was impossible to effect orderly termination of operation on the above date. Accordingly, on September 27, 1945, another modification was issued extending the date of termination with regard to refineries affected by these factors.

On January 15, 1946, an amendment was executed transferring to the Army-Navy Petroleum Board the authority, theretofore exercised by PAW, to recommend payment of claims and specifying that no further claims would be accepted after January 31, 1946, unless notice of intention to file a claim was filed with PAW by that date. With this final adjustment, PAW's duties under the plan and the plan itself were brought to a close.

Expenditures.—Government expenditures for reimbursement claims as of June 30, 1946, were approximately:

Year	91 octane		100 octane		Total	
	Claims	Amount	Claims	Amount	Claims	Amount
1942	3	$14	26	$5, 497, 461	29	$5, 497, 475
1943	6	219, 134	69	28, 641, 307	75	28, 860, 441
1944	8	358, 574	99	62, 347, 492	107	62, 706, 066
1945	2	7, 159	104	29, 490, 236	106	29, 497, 395
Grand total	19	584, 881	298	125, 976, 496	317	126, 561, 377

Altogether there were 317 claims covering both 91- and 100-octane gasoline, with the latter figuring in the bulk of claims. The total governmental expenditure amounted to approximately $126,561,377.

Of the above total expenditure, $878,091 or approximately 0.7 percent was paid by the Government for extraordinary capital losses mentioned earlier in the report. These losses—represented by 30 claims—arose out of installation (made at PAW's request) of specialized minor facilities which were of no use once the war emergency was over. Of the two principal types of such facilities, those involved in cumene substitute blending had a cost of from two to three thousand to seventy thousand dollars each and typically included small storage drums, piping, one or two pumps, and extensive concrete work. The installation cost of the second class of facilities was usually quite low having as a maximum a cost of from 15 to 25 thousand dollars for a single job. These minor facilities on which capital losses were paid were those which had to be erected on short notice and which were operated under the Reimbursement Plan. The refiners made no additional profit on the facilities or their operation.

THE FOUR PARTY PURCHASE AGREEMENT

The problem.—To produce maximum quantities of 100-octane aviation gasoline for the war emergency it was necessary to develop within the Government some pattern of procurement. In order to justify the investment of many millions of dollars per refinery for the expansion of productive capacity, refiners properly felt the need for firm Government contracts under which demand might be assured for a reasonable period of time. Neither the Army nor the Navy, the principal users of the product, had the right to contract to purchase any product for a period longer than the fiscal year in which it was working—a time period too short to justify the financial commitment required.

The problem was solved in November 1941, when upon urging by the Petroleum Administration for War, it was agreed that the Reconstruction Finance Corporation, or its subsidiaries, would enter into long-term contracts to purchase aviation gasoline produced from new facilities to be constructed by the oil companies. The Army and Navy in turn agreed with RFC that they would reimburse that agency for its expense out of future military appropriations, when granted.

These understandings broke the impasse. A series of contract negotiations was therafter initiated with refiners, on the basis of which the entire production of 100-octane aviation gasoline ultimately was purchased through the Defense Supplies Corporation. Such contract negotiations were undertaken by PAW and continued, as aviation gasoline requirements expanded throughout the war.

Toward the latter part of 1942, it became obvious that it would be necessary to integrate more closely the purchasing arrangements with the extraordinary operations required to provide the necessary quantities of product. Accordingly, on December 19, 1942, the Four Party Purchase Agreement was entered into, bringing up to date the understandings of November 1941, and relating these purchasing arrangements to the provisions of the aviation gasoline reimbursement plan. The PAW, DSC, and the War and Navy Departments were signatories to the new agreement.

Terms and modifications.—Under the purchase agreement all 100-octane gasoline manufactured after January 1, 1943, was to be purchased by Defense Supplies Corporation. In turn, DSC resold the gasoline to the Army and Navy and other authorized consumers at a country-wide uniform price, f.o.b. the refinery of manufacture. The uniform price was established by the Petroleum Administration for War at a level to average the various individual contract prices and to include the costs of the aviation gasoline reimbursement plan, the costs of the extraordinary construction expenses of privately-owned facilities beginning January 3, 1944, and Defense Supplies Corporation's administrative costs.

Under the agreement, Defense Supplies Corporation entered into fixed-price and cost-type supply contracts (usually running 3 years) covering the purchase and sale of 100-octane aviation gasoline and components thereof. All contracts signed by DSC were negotiated by PAW and entered into on the recommendation of the Petroleum Administration for War, acting on advice of the military authorities as to military requirements for aviation fuel. A committee headed by a PAW representative, and composed of representatives from the War and Navy Departments and DSC met from time to time to administer the details of the agreement.

The Four Party Purchase Agreement originally was effective for the period January 1, 1943, through June 30, 1943. On May 20, 1943, it was revised and extended through June 30, 1944. On January 3, 1944, it was supplemented by a provision allowing reimbursement for expenditures properly incurred in an effort to expedite the Construction, conversion, alteration, or expansion of privately owned war product facilities.[3] On July 1, 1944, the content of this supplement was made a part of the aviation gasoline reimbursement plan.

Revised conditions and experience gained in operation under the agreement made it desirable to effect—without altering the basic features—certain clarifications and modifications. The expiration of the original understanding on June 30, 1944, offered a propitious occasion for effecting these changes; and accordingly, on July 1, 1944, a new agreement incorporating appropriate revisions and superseding the previous understandings, was signed. A year later this agreement was extended until June 30, 1946.

When VJ-day became imminent, steps were taken by PAW to terminate the aviation gasoline supply contracts. Despite the fact that most were terminated by the first part of October 1945, there remained considerable work to be undertaken in effecting an orderly liquidation of the transactions under the agreement. With the bulk of this completed by the first part of 1946, the responsibilities of PAW were, by an amendment dated January 15; transferred to the Army-Navy Petroleum Board.

Expenditures.—Governmental disbursements effected by DSC under the Four Party Purchase Agreement amounted as of June 30, 1946, to $2,202,267,571. A few damage claims arising out of contract terminations—estimated to amount to approximately $50,000,000—are still awaiting settlement; but the likelihood is that final adjustments, while raising gallonage figures, will not appreciably alter total expenditures. In return for the expenditure of this amount of money, 13,913,663,862 gallons of aviation gasoline were delivered for the Army and Navy account.

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PART 3.—REFINERY CONSTRUCTION LOAN PROGRAM

The problem.—The pattern of aviation gasoline procurement policy as carried out by Defense Supplies Corporation with the advice of PAW on behalf of the Army and Navy was, in the case of gasoline to be purchased from privately owned facilities, a 3-year firm purchase contract. This was the briefest term which seemed to be feasible, although all parties hoped that the war might terminate sooner. In furtherance of these contracts arrangements were effected under which Defense Supplies Corporation offered to loan up to 75 percent of the estimated cost of new refining facilities to be constructed by private capital. These loans were interest-bearing but were not directly associated with the facilities themselves, becoming instead general obligations of the borrowing company.

There were in general two types of loan contracts: The first required repayment of the contracted loan in cash, in monthly installments; the second required repayment in refinery products. There were 27 contracts of the first type, 5 of the second. In all, 18 operators executed such contracts with the Government, and 16 of these actually availed themselves of the loan provisions. Two operators having together four contracts borrowed no money under any of the contracts.

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[3] See Extraordinary Construction Expenses Program, infra, p. 366.

Expenditures.—Under the two types of contracts negotiated, approximately 245 million dollars was disbursed. Of this a little more than 45 percent, as of June 30, 1946, was repaid, with 5 companies having repaid their loans in full. Loans of the other 11 are either being liquidated in the normal course of business or are suspended, as anticipated when the loans were made, pending negotiations with the Government as to offset and damage claims resulting from contract terminations after VJ-day.

EXTRAORDINARY CONSTRUCTION EXPENSE PROGRAM

The problem.—The 100-octane gasoline construction program was directed toward the expansion in the quickest possible time of the production of aviation fuel through the creation or modification of refining facilities.[9] While there were a number of defense plant projects in the total program more than three-fourths of the program (measured either in barrels of end product or in dollars) was privately financed.

It was the duty of PAW to see to it that materials needed for the erection of refineries were made available in an orderly and dependable fashion. To do this a number of devices were employed to expedite deliveries of equipment to the operators who actually undertook the construction job. As the demands for product increased and the problems of expediting deliveries grew more complicated, it became necessary to resort to uneconomic means in order that necessary equipment could be delivered to plants at the earliest practicable moment.

After considerable study of the delays that were being experienced in completing 100 octane gasoline projects, the representative of the War Department to the Special Inter-Agency 100 Octane Gasoline Committee recommended late in 1943 that there be established some method of reimbursing the constructing companies for extraordinary expense expediting construction, just as the companies were already being reimbursed for extraordinary actions taken to increase the production of aviation gasoline from facilities that were already finished. This type of expediting action appeared to be entirely proper in the case of those companies which had contracted to supply the government with 100 octane gasoline at a fixed price, since the cost and price factors involved in the contract naturally could not have taken into account the terrific dislocations and construction delays that were being experienced throughout the war program. It was suggested that such reimbursement be offered for extraordinary expenses which might be involved in following the specific recommendations of the Special Inter-Agency 100 Octane Gasoline Committee.[10]

After detailed consideration of this recommendation, it was agreed, in the light of the urgent demand for aviation gasoline, that such a step should be taken; and accordingly on January 3, 1944, a Four Party Inter-Agency Agreement was entered into by the Army, the Navy, DSC, and PAW to carry the recommendation into effect.

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[9] See Government Financed Aviation Gasoline and Related Facilities Program, infra, p. 367.

[10] The unusual procedures contemplated included the use of maximum overtime, the use of extraordinary methods for the delivery of equipment and material (such as express or air shipment), the employment of a super abundance of engineers, lay-out men, extra supervisors, and additional foremen.

Terms and modifications.—The agreement provided for the reimbursement of extraordinary expenses of the types referred to where incurred in the construction, conversion, alteration, or expansion of privately owned facilities, and where approved in advance by the PAW with the concurrence of the War or Navy Department's representative appointed for that purpose. Under the agreement, the extraordinary expenses were to be paid by the Defense Supplies Corporation which was to be fully reimbursed under the Four Party Purchase Agreement in the sale of the product to the Army and Navy.

On July 1, 1944, this agreement was made a part of the aviation gasoline reimbursement plan (see discussion of the Aviation Gasoline Reimbursement Plan and Four Party Purchase Agreement) and continued in this form until terminated. For practical purposes the extraordinary construction expense program expired on August 15, 1945, when most of the gasoline purchasing contracts between DSC and the various refining companies were cancelled. Formal expiration of the plan was brought about on January 15, 1946, when PAW transferred its duties under the Aviation Gasoline Reimbursement Plan to the Army-Navy Petroleum Board.

Expenditures.—Reimbursement by the Government for extraordinary construction expenses was offered and accepted on 18 projects. On 15 of the projects use was actually made of the program. The total amount expended for reimbursement of extraordinary construction expenses was approximately $7,296,000; while the total cost of the projects receiving reimbursement was approximately $240,000,000. Reimbursement for extraordinary expenses amounted, therefore, to slightly more than 3 percent of the total amount expended on the projects to which it was applied.

While it is impossible to determine accurately the saving in construction time resulting from these expenditures, it is estimated that completion of the projects was accelerated in most cases from 1 to 3 months. Assuming that acceleration was only 1 month, over 2,000,000 barrels of additional gasoline were obtained at a time when this product was vitally needed. If the total expenditures are charged against this quantity of added product, the resulting premium is something over 7 cents a gallon—considerably lower than that paid or much of the marginal gasoline produced by extraordinary methods in order to supply minimum military requirements.

AVIATION GASOLINE AND RELATED FACILITIES PROGRAM

The problem.—Despite the tremendous privately owned construction program and the Government financing programs undertaken to obtain additional quantities of aviation gasoline through extraordinary methods of operation, requirements for the product were still larger than could be met through these means. Moreover, while it was possible for many of the larger operators to undertake the construction of refining facilities without direct government assistance, such was not the case in respect to the smaller elements of the industry. Further, many of the new facilities required for the production of 100 octane were at the time of their installation comparatively costly both as to initial investment and operating costs. In addition, with respect to certain of the processes employed and the products produced, there was grave doubt as to postwar utility—especially where installed in association with the smaller refineries.

In these circumstances it was necessary to call upon the Government to undertake the construction of additional aviation gasoline refining capacity. To this end, arrangements were made between the Petroleum Administration for War and the Defense Plants Corporation, a subsidiary of RFC, and various operators who would oversee the construction of the plants and undertake their operation once installed. Operating contracts were negotiated and signed with these operators during 1942 and a part of 1943, and construction was started on the units as quickly as the operating contracts could be reduced to final form and materials made available.

Further, to assist in carrying on the aviation gasoline program it was necessary to reach agreements for the construction of government-owned facilities to produce synthetic catalyst to be used in the newly erected catalytic crackers. It was also necessary, in order to expedite the construction program, to utilize direct Government financing in a few minor instances, in obtaining additional capacity for the manufacture of scarce items of badly needed equipment and components entering into aviation gasoline production.

Contract terms.—Two types of contracts were negotiated with operators of government-owned refining facilities: (1) Lease agreements under which the plants were constructed for and leased from the Defense Plants Corporation; and (2) supply arrangements under which the products were purchased by the Defense Supplies Corporation.

Under the lease agreements all construction expenses were paid by DPC; however, no profit and generally no overhead charges accrued to the operator. Under the agreements, the operator leased the particular facility for a period ending as of the termination of the DSC supply contracts. Upon termination of the lease contract, options became effective giving the operator a right to purchase the facilities involved at whichever of the following three bases represented the greatest return to the Government: (*a*) Original cost less 10 percent per year depreciation; (*b*) original cost plus 4 percent interest, less rental paid plus 4 percent per year interest; or (*c*) 15 percent of the original cost. Options giving an exclusive right to purchase remained in effect, unless waived by the lessee-operator, for a period of 6 months after termination of the operating contract. For a period of 90 days after the exclusive right to purchase expired an operator was granted the privilege of first refusal. These options, not being sufficiently favorable to the refiners, were not exercised.

Disposal of gasoline produced through the operation of the government-owned refining facilities was effected under supply contracts which were forerunners of those drafted pursuant to the arrangements established in the Four Party Purchase Agreement. There were two types of supply contracts: (*a*) A negotiated price contract under which gasoline was produced and sold at a price negotiated with the operators by Government representatives; and (*b*) a cost plus fixed fee contract in which the operator received an operating fee based upon the number of gallons produced and containing a contingency provision to cover emergency conditions. There were originally several negotiated price contracts, but only two Defense Plant operators continued or operate under such contracts throughout the war period. On the other hand, virtually all of the operators of privately owned plants continued throughout the war on fixed price contracts which, in general, were more favorable to the Government.

In two cases operators originally working under negotiated price contracts felt that because of the unanticipated construction cost of the installed facilities and other factors, such a contract would result in operations at a continuing loss. After consideration these contracts were adjusted to a cost type contract, containing, however, no operating fee provisions. Under this modification of the cost-plus type contract, operators were held harmless against losses which might be incurred in the operation but received no profit from the undertaking. Altogether five contracts of this type were negotiated. Two companies voluntarily chose no profit.

In addition to the plants constructed under operating contracts of DPC, there were four installations erected under contracts negotiated with PAW and executed by DSC. Under the latter contracts the plant was constructed by the operator in large part with his own funds but was returnable to the Government in the event that the operator did not elect to continue operation after termination of the war emergency, the Government agreeing to reimburse the operator for his cost of construction in the event that the facility was returned. Evaluation of the units for the purpose of settling the contracts was to be based upon the original cost less depreciation.

The four facilities constructed under these contracts, two of which were escrow arrangements, were: (*a*) An alkylation and isomerization unit and associated facilities, constructed by Champlin Refining Co. at Enid, Okla., at a cost of approximately $3,743,000; (*b*) an alkylation and isomerization unit and related facilities constructed by the Cities Service Oil Co.[11] at East Chicago, Ind., at a cost of approximately $2,793,000; (*c*) an isopentane plant constructed by the Continental Oil Co. at Wichita Falls, Tex., at a cost of approximately $71,900; and (*d*) a BB extraction unit constructed by the Socony-Vacuum Oil Co., Inc., at East St. Louis, Ill., at a cost of approximately $212,000.

In respect to the catalyst and the other Government-financed facilities related to the aviation gasoline program, no supply contracts with DSC were negotiated—the products being disposed of through normal marketing arrangements. The operating contracts under which the plants were constructed and operated were the standard arrangements entered into by DPC and were similar in form, scope, and terms to those negotiated in connection with the construction of the aviation gasoline plants themselves.

Expenditures.—As of June 30, 1946, net Government disbursements for the construction of aviation gasoline facilities amounted to

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[11] This was the first 100-octane contract under the Defense Program and the only one signed before Pearl Harbor.

$235,836,850.80.[12] In return for the expenditure of this sum, 29 aviation gasoline installations and 1 toluene facility were erected, at the recommendation of PAW. These installations listed below were completed under 25 plancor numbers of the Defense Plant Corporation:

Plancor No.	Operator	Plant location	Amounts expended
880	J.S. Abercrombie Co. and Magnolia Petroleum Co	Sweeny, Tex	$28, 177, 709. 21
1036	Anderson-Prichard Refining Co	Cyril, Okla	244, 484. 31
1067	Ashland Oil & Refining Co	Catlettsburg, Ky	16, 562, 939. 75
1059	Associated Refineries, Inc	Becket, Okla	14, 685, 364. 16
1229	Bay Petroleum Corp	Denver, Colo	128, 361. 43
882	Continental Oil Co	Ponca City, Okla	1, 303, 988. 91
1042	do	do	17, 232, 228. 33
959	Cooperative Refinery Association	Coffeyville, Kans	6, 078, 598. 04
1068	Crown Central Petroleum Corp	Pasadena, Tex	16, 141, 548. 44
911	Eastern States Petroleum Corp	Houston, Tex	11, 674, 058. 66
1146	Frontier Refining Corp	Cheyenne, Wyo	8, 121, 851. 86
638	Great Southern Corp	Corpus Christi, Tex	8, 049, 610. 71
638	Chicago Corp	Agua Dulce, Tex	840, 739. 89
638	Lockhart Oil Co	Banquete, Tex	416, 893. 29
638	Chicago Corp	Bishop, Tex	868, 003. 76
638	Gulf Plains Corp	Driscoll, Tex	932, 286. 84
1909	Humble Oil & Refining Co	Baytown, Tex	4, 406, 080. 42
1041	Mohawk Petroleum Corp	Bakersfield, Calif	4, 648, 202. 71
1871	Pan-American Refining Corp	Texas City, Tex	2, 914, 176. 50
1044	Pennzoil Co	Oil City, Pa	4, 490, 863. 00
592	Premier Oil Refining Co	Cotton Valley, La	6, 587, 768. 95
562	Pure Oil Co	Smith's Bluff, Tex	3, 424, 674. 11
718	Republic Oil Refining Co	Texas City, Tex	11, 314, 100. 63
689	Root Petroleum Co	El Dorado, Ark	6, 220, 882. 90
591	Southport Petroleum Co. (present name: American Liberty Oil Co.).	Texas City, Tex	11, 723, 843. 96
1833	Standard Oil Co. of California	Richmond, Calif	21, 214, 032. 23
1868	Standard Oil Co. of New Jersey	Baton Rouge, La	3, 693, 037. 54
1164	Utah Oil Refining Co	Salt Lake City, Utah	15, 458, 284. 46
1164	do	Fort Laramie, Wyo	
912	Wilshire Oil Co., Inc	Norwalk, Calif	8, 282, 235. 80
	Total		235, 836, 850. 80

In addition, the Government expended $8,472,536.27 upon plants for the production of catalysts used in the catalytic cracking process. The five projects and their costs were:

Plancor No.	Operator	Plant location	Amounts expended
1258	American Cyanamid & Chemical Co	Fort Worth, Tex	$3, 557, 331. 53
1343	Chicago Chemical Co	Chicago, Ill	972, 986. 83
2440	Davison Chemical Co	Baltimore, Md	120, 421. 02
1458	Diakel Corp	Cincinnati, Ohio	2, 764, 142. 56
1324	Houdry Process Corp	Paulsboro, N. J	1, 057, 654. 33
	Total		8, 472, 536. 27

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[12] Excluded from this figure is an outlay of $194,131 paid by the Government to the Charter Refining Co. for the settlement of a contract under which a plant was to be constructed. No plant was built, but certain costs in contemplation thereof were incurred. Omitted from this figure is an amount totaling $1,490,189 expended by the Government under plancor No. 593 for the construction of facilities at Corpus Christi, Tex. These facilities subsequently were taken over by the Sinclair Refining Co., which reimbursed the government for the amounts theretofore expended. Also omitted are certain installations initiated by other agencies or jointly with PAW and utilized for a time in connection with the 100-octane program under the sponsorship of PAW. These embraced plancor No. 938, a toluene facility, operated by Magnolia Petroleum Co., located at Beaumont, Tex., constructed under an authorized expenditure of approximately $3.136,181; plancor No. 1065, a toluene facility used for production of aviation gasoline components, operated by the Standard Oil Co. of Louisiana (now Standard Oil Co. of New Jersey, Louisiana Division), located at Baton Rouge, La., costructed under an authorized expenditure of $3,252,517; and plancor No. 1868, a facility used for the production of aviation gasoline components, also operated by the Standard Oil Co. of Louisiana, located at Baton Rouge, La., constructed under an authorized expenditure of $3,693,037.

Besides expenditures for aviation gasoline facilities and catalyst producing plants, the Government disbursed $433,014.24 for construction of four projects of an auxiliary nature, such as plants producing equipment for refining facilities or components entering into gasoline production. The four projects and their costs were:

Plancor No.	Operator	Plant location	Amounts expended
2197	Cameron Iron Works, Inc	Houston, Tex	$158, 637. 81
2072	Pennsylvania Salt Mfg. Co	Philadelphia, Pa	67, 679. 60
[1] 2311	Southwestern Engineering Co	Los Angeles, Calif	156, 154. 51
[1] 1894	Standard Oil Co (Onio)	Cleveland, Ohio	50, 542. 32
	Total		433, 014. 24

[1] Complete units or plants were not constructed. Government funds were used to install equipment only.

Total governmental disbursements under the PAW sponsored program of aviation gasoline facilities, catalyst producing and auxiliary projects amounted to approximately $250,000,000.

In connection with the foregoing, the Government approved the disbursement of an additional $3,724,000 for four projects. This sum was never expended since the facilities to be constructed thereunder were, for various reasons, never erected. Of the four proposed projects enumerated below, the first was for aviation gasoline facilities, the remaining three were plants of an auxiliary nature. The approved costs were:

Plancor No.	Operator	Location	Approved amount
1951	Sun Oil Co	Marcus Hook, Pa	$3, 172, 000
[1] 2147	Hanlon-Buchanan, Inc.	Lake Charles, La	500, 000
[1] 1890	Lion Oil Co	El Dorado, Ark	50, 000
[1] 2318	National Supply Co	Toledo, Ohio	2, 000
	Total		3, 724, 000

[1] Built on private ownership basis.

Obviously, no final balance sheet covering actual cost of this program to the Government can be drawn until disposal has been effected and payment made. Negotiations as to disposal were never a function of the Petroleum Administration for War, such matters being governed by the provisions of the Surplus Property Act.

THE PIPELINE PROGRAM

The problem.—Historically, the east coast has been dependent upon tanker transportation for the bulk of its supplies of petroleum and petroleum products. As the demands of war and enemy action resulted in loss of this means for bringing in oil, alternative facilities had to be provided. The pipe line construction program was a part of the over-all plan devised by PAW to provide the necessary means for moving the oil.[15]

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[15] The pipe line construction program and its relation to the use of other means of transportation are handled in detail in the chapter on Supply and Transportation.

Six major projects were undertaken by the Government as a part of the over-all pipe line program. All of these were directly or indirectly related to the eastward movement of petroleum or petroleum products. In total length, these Government lines measured almost 3,500 miles, approximately 25 percent of the total pipe line milage constructed during the war. In cost, the Government-sponsored program was approximately 50 percent of the total wartime expenditures for pipe line construction, alterations, and conversions.

The two most dramatic lines were the Big Inch and the Little Big Inch. The Big Inch, a crude line, constructed out of 24-inch pipe, stretched from Longview, Tex., to the New York-Philadelphia area. The Little Big Inch is a 20-inch products line extending from Beaumont, Tex., to Linden, N.J.

The other four projects were: (*a*) Southwest Emergency, extending from Refugia to Pierce Junction, Tex., a distance of 154 miles, and providing petroleum for the Big Inch system; (*b*) Ohio Emergency, running from Tiffin to Boylestown, Ohio, and providing a necessary eastward connecting link between existing lines and refineries; (*c*) Florida Emergency, an 8-inch line, 200 miles long, running from Carrabelle to Jacksonville, Fla., and providing a connection across the neck of Florida for petroleum moving cast by barge along the inland waterways; and (*d*) Plantation Extension, an 8-inch line, 175 miles long, running from Greensboro, N.C., to Richmond, Va., and providing needed products at points along the central Atlantic States.

Construction and operating arrangements.[16]—In order to carry out the Government-financed portion of the pipe line program, a series of contractual and organizational arrangements were made whereby the best pipe line personnel of the petroleum industry could be drawn upon for necessary construction and operation. Three nonprofit Government corporations, especially established to do the war job, undertook construction of four of the projects. The other two were constructed and operated by existing private organizations, also on a nonprofit basis.

War Emergency Pipe Lines, Inc., a Government corporation, constructed and operated the Big and Little Big Inch Pipe Lines. Florida Emergency was constructed and operated by the second Government corporation, the Florida Emergency Pipe Line Company. Ohio Emergency Pipe Lines, Inc., the third Government corporation, undertook the construction of the Ohio Emergency line, but operation was undertaken by the Standard Oil Co. of Ohio under a nonprofit operating contract entered into with DPC.

The Southwest Emergency Pipe Line project was constructed and the line operated on a nonprofit basis by the Humble Pipe Line Co., acting as agent for the Defense Plants Corporation.

The Plantation Extension Pipe Line running from Greensboro, N.C., to Richmond, Va., was constructed and operated by the Plantation Pipe Line Co., also on a nonprofit basis as agent for DPC. All of the operating contracts entered into with the various privately owned pipe line companies contemplated payment by the Government only for the expenses involved, with all operating profits, less expenses, returnable to the Government.

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[16] For operational and technical details of the five pipe lines mentioned in the following account, see ch. VII and appendix 11.

Expenditures.—A final evaluation of the cost of the Government-sponsored pipe line program must await final disposition of the government-owned lines, a matter under the jurisdiction of the War Assets Administration. Further, revenues received from movements of crude oil or products through the lines must be offset to an as yet unknown extent by payments made under the Compensatory Adjustments Program (see p. 362, above); and while this latter consideration does not affect the over-all validity of the figures given in this appendix, it does prevent a precise measurement of net gain or loss to the Government.

Financial considerations are summarized project by project:

1. Big Inch:	
Cost	$79,107,044
Barrels of oil moved	274,783,329
Net income	[1] $122,140,878
2. Little Big Inch:	
Cost	$68,568,240
Barrels of product moved	111,640,092
Net income	[1] $60,360,390
3. Florida emergency:	
Cost	$4,211,312
Barrels of product moved	19,549,286
Net income	[1] $2,773,745
4. Ohio emergency:	
Cost	$1,505,763
Barrels of oil moved	17,677,288
Net income	[1] $1,067,870
5. Southwest emergency:	
Cost	$6,132,584
Barrels of oil moved	52,161,277
Net income	[1] $3,700,819
6. Plantation extension:	
Cost	$3,405,284
Barrels of oil moved	21,795,557
Net income	[1] $3,273,850

[1] Net income is equal in all cases to total gross operating income plus revenues from rents (if any) less operating costs, gathering and transportation charges and takes.

The total cost of the Government facilities was $162,930,227. The total net income to the Government through movement of crude and products through the facilities was $193,317,552. The total number of barrels moved was 497,606,829.

In determining the cost of the pipe line construction program to the Government, net income figures may be treated as offsets to construction expense or offsets to expenses incurred in the eastward movement of oil under Petroleum Compensatory Adjustments Regulation No. 1 (supra, p. 362). As has been indicated above, if this latter approach is adapted the cost of the Compensatory Adjustments Program is materially reduced and a determination of the net cost of the facilities as such must await sale or other disposition by WAA.

ACCELERATED AMORTIZATION PROGRAM

The problem.—As efforts to establish adequate defense facilities got under way in the latter part of 1939 and the early part of 1940, the reluctance of industry in general to enlarge capital installation became increasingly apparent. Accordingly, as an inducement toward the investment of private funds in facilities which would be needed in the event of war, the Internal Revenue Code was amended to include a provision [18] permitting the accelerated amortization of emergency facilities erected, constructed, or installed for national defense. This inducement provision, effective throughout the war, allowed taxpayers to write off the cost of new facilities over a 5-year period (or less should the emergency end sooner) instead of over the longer depreciation period normally used.

Administration of accelerated amortization certifications, known as necessity certificates, was originally in the hands of the War and Navy Departments—a particular case being processed by one or the other according to which had the greater contractual interest in the product to be produced by the facility.[19] In December 1943 responsibility for the issuance of necessity certificates was transferred to WPB and in September and October 1944 the remaining functions of the accelerated amortization program were likewise transferred to WPB and later to its successor agency, the Civilian Production Administration.[20] During the life of the entire program, PAW had no direct final operating responsibility and no voice in establishing the general policies which were developed, although at all times PAW made recommendations under standards prescribed by the administering agencies on cases submitted to it which were directly a part of the petroleum program and which covered facilities under PAW jurisdiction.[21] In some instances, accelerated amortization of petroleum facilities was approved without reference to PAW, since the solicitation of a PAW recommendation was always at the option of the administering agency.

Under the program there were three types of determinations upon which recommendations from PAW were solicited: (*a*) Necessity certificate; (*b*) nonnecessity certificate; and (*c*) necessity certificate amendments. The necessity certificate was evidence of a determination, known as "scope determinations," that the facility to be constructed was necessary in the interests of national defense. As has been indicated, the issuance of a necessity certificate permitted the taxpayer to amortize the facility in at least 5 years. The nonnecessity certificate was evidence of a determination that the facility or facilities covered by a necessity certificate were no longer needed for national defense. It gave effect to that aspect of the necessity certificate and the regulations which permitted the writing off the facility during a period of less than 5 years. The scope determination was an amendment to the necessity certificate permitting revisions in descriptions and adjustments in estimated costs so as to reflect accurately the final descriptions and costs of the originally certified facility. It was literally a finding that the facility as installed was "within the scope" of the facility originally certified. An amended application could never be used to obtain accelerated amortization for installations of facilities not authorized in the original necessity certificate.

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[18] Section 124 of the Internal Revenue Code.

[19] Where the particular facility (such as a crude pipe line) manufactured no product usable as such by one service or another, or where there was no predominant direct contractual interest (as in the case of a manufacturer of subassemblies), processing procedures were irregular and caused serious difficulties during the early stages of the program.

[20] Executive orders No. 9406, Dec. 17, 1943; No. 9486, Sept. 30, 1944: and No. 9490, Oct. 20, 1944.

[21] For example, PAW made no recommendations on the installation of carbon black facilities except to indicate the need of the product, and in many cases even this was not done. Primary jurisdiction for carbon black facilities rested with the Chemicals Bureau of WPB. Similarly, after the establishment of ODT, PAW did not assume primary responsibility for recommending tank cars, barges, tug boats and the like, although in instances PAW opinion as to need from the petroleum standpoint was solicited.

PAW was primarily concerned with recommendations on application for necessity certificates and amendments thereto. Since most certified petroleum facilities were in war service until the termination of hostilities, PAW had little occasion to consider or recommend nonnecessity certificate action.

Standards.—Throughout the war the administering agencies established regulations approved by the President, covering the standards to be used in analyzing and recommending action on applications under the accelerated amortization program. The early period, from the summer of 1940 to the beginning of 1942, was devoted in large part to the evolution of principles and clarification of concepts. Such standards as were developed were extremely flexible, and were changed from time to time as experience under the program required adjustments.

By January 1942 the formative period was largely completed—the regulations became crystallized; the procedure for analyzing applications and issuing certificates was perfected; one basic test for determining the eligibility of facility for accelerated amortization privileges was devised—that the facilities proposed contributed directly and immediately to the supply of a critical material in short supply and required for the war program. This general situation prevailed until October 1943, during which time PAW recommended several hundred certificates.[22] It was not PAW's responsibility at this time or later to determine conformity of the applications with technical phases of the regulations, and accordingly, PAW made no recommendations as to dates, adequacy of description, or the like.

In the autumn of 1943, upon the basis of a WPB recommendation that with few exceptions the United States possessed the necessary capital equipment to assure victory, the regulations covering the issuance of necessity certificates were considerably tightened. Under an amendment to the regulations, approved by the President on October 5, 1943, the issuance of necessity certificates was limited to those applications which could meet not only the standard then being used—the so-called "shortage test" set forth above, but also a second criterion, that it was to the advantage of the Government that the proposed facilities be privately financed. This second criterion, which came to be known as the "post-war utility test," was continued in effect until the program was terminated.

Application of the postwar utility test involved considerable difficulty and it was necessary to obtain a further definition of the standard before PAW could process applications. After a series of conferences with officials of WPB, an exchange of correspondence occurred early in 1944 in which WPB confirmed the interpretation which it wished followed in applying the standard to petroleum industry cases. Upon the basis of this exchange of correspondence, petroleum applications were thereafter reviewed.

In order to assure that such a review was uniform within PAW and in conformity with the expressed policies of WPB and the President, special arrangements were made by which all necessity certificates received, in addition to the review of the Operating Divisions, a special review by the Legal Division and the Assistant Deputy Administrator, or in the latter's place, a representative of the Deputy Administrator. This review, instituted at the end of 1943 and continued until PAW duties under the program ended, assured full and independent review of each case and impartial and consistent treatment for all applicants.

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[22] During the period up to October 1943, the War and Navy Departments approved over 27,000 necessity certificates in all industries having a value (as estimated by the applicant at the time of application) in excess of $5,500 million.

With the progress of the war, it became evident that there would be instances where facilities originally constructed for war purposes were no longer needed in the war program. Under the provisions of section 124 of the Internal Revenue Code, provision had been made for issuing so-called "nonnecessity certificates" which would, if issued, permit the taxpayer to write off a certified facility during the period between its initial operation and the time it was declared no longer necessary for war purposes. Accordingly, on September 30, 1944, the President issued regulations to carry this provision into effect, and on the same date transferred the administration of this function from the War and Navy Departments to the War Production Board. Although PAW was called upon to recommend the issuance of nonnecessity certificates as it had been requested to recommend necessity certificates, the continued direct relationship between petroleum facilities and military operations made the number of cases referred to PAW prior to VJ-day insignificant. With the end of hostilities it became obvious that most facilities, in petroleum as well as in other industries, would be eligible for nonnecessity certificates, and accordingly a general determination to this effect was issued by the President, thereby relieving the agencies of the tremendous administrative burden involved in making individual determinations.

Under the regulations prescribed by the certifying authorities and approved by the President, provisions were made whereby the taxpayer could apply for an amendment to a necessity certificate when it was found that the actual descriptions and costs of the certified facilities materially varied from those appearing in the original necessity certificate. These amendments were to be granted wherever, in the opinion of the certifying authority, the revised descriptions and costs were within the scope of the original certification.

The problem faced by PAW was to advise, within the standards prescribed by the administering agency, whether or not in its opinion the revised descriptions and costs were within the scope of the original certification. To the extent that revised descriptions and costs came about through uncertified modifications or additions, no amendment could be granted and such amounts had to be disallowed. Obviously, such findings were extremely difficult, especially in the petroleum industry, and numerous close questions arose. In order to assure conformity in treatment among divisions and with respect to applicants, especially as to difficult cases, the same centralized review as was used in the case of original recommendations was adopted and continued until PAW's responsibility for accelerated amortization recommendations terminated in March 1946.

Amounts authorized.—There is, of course, no method of evaluating the reduced revenue, if any, to the Government, or the benefit of the war program, arising through the use of accelerated amortization privileges. In the first place, such an evaluation would differ in each case, depending upon the relative tax position of each taxpayer and the amount of accelerated amortization permitted. In the second place, it would depend upon earnings received over the normal depreciation period and the tax policy of the Government during that same time.

PAW records do not disclose in full the dollar amount of accelerated amortization which was received by the petroleum industry. In some instances, especially during the early period, cases were handled by the administering agency without reference to PAW for recommendation. Even where cases were referred, the PAW recommendations could be, and sometimes were, altered by the administering agency in passing finally upon the case. The nature and extent of such alterations were never disclosed to PAW unless the case was again referred to PAW in connection with a nonnecessity certificate or an amended application. In some instances necessity certificate amended applications were processed by the administering agency without reference to PAW, even in cases where PAW had been solicited for a recommendation on the original necessity certificate application. In those cases where PAW responsibility was secondary even as to recommendation, such as with respect to the transportation facilities other than pipe lines and terminals, the dollar records cannot be considered as other than indicative of the fact that sizable certifications were made.

From the foregoing, in which it is pointed out that accelerated amortization was brought into being as an incentive to increase the expenditure of capital for the construction of facilities needed for national defense, it should be evident that a high percentage of the requests for more rapid amortization on the large projects required by the petroleum industry, especially in the transportation branch, were processed during the period when the War Department and the Navy Department had the full responsibility for making determinations as to their necessity. Although later, when the responsibility was transferred to WPB, PAW, as an adviser on petroleum projects, received some of the older projects for further consideration, nevertheless, at no time did PAW receive reports from the responsible agency or agencies as to the amounts of money ultimately involved. PAW knew the final details of amounts cleared only in a fraction of the cases either in numbers or in dollars.

When it came to preparing a statement on this phase of Government financing, it was anticipated that some recapitulations probably would be available from which a few figures could be extracted that would tell the total amount of accelerated amortization allowed for petroleum facilities. Such did not prove to be the case. To have secured summarized figures it would have been necessary to spend hundreds of man hours for research and accounting as it would have involved, first, separating petroleum projects from the records by handling the oil industry projects one by one, and then by accounting methods to have arrived at definitive figures.[23] As anything less than an accurate statement could not be tolerated, and as the personnel available for research on PAW history was indeed most limited, it was, in the circumstances, necessary to drop the subject.

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[23] Months before this book went to press the project control section of WPB had been liquidated and the files transferred to dead storage.

From PAW records it is known that the dollar amount of accelerated amortization certificates allowed to the petroleum industry was large, running into many hundreds of millions; but of the exact amount, that must await further research.

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THE TECHNICAL OIL MISSION

The idea of tapping the technical oil knowledge of our enemies was first proposed to the military by Director Snodgrass of PAW's foreign refining division in the fall of 1943, but his proposal elicited little interest at the time.

Early in the summer of 1944, however, the subject was revived in a strong recommendation from Administrator Ickes to Fleet Admiral Leahy. On behalf of the Joint Chiefs of Staff, Admiral Leahy agreed to the urgency of such a mission; and steps were taken to enlist the active support of the other interested Government agencies.

The Enemy Oil Committee was of great assistance in this effort. In fact, a working group [18] under this committee prepared a complete organization plan with the assistance of staff officers fresh from the field. Unfortunately, this plan was not implemented and the mission as finally evolved went forward without a military leader.

At the same time, PIWC's technical committee and its technical advisory committee joined in urging the prompt setting up of a mission to go into enemy refineries as quickly as possible behind the invading armies on the theory that, unless the information was obtained quickly, it might not be obtainable at all.

In urging the prompt organization and dispatch of such a mission, the TAC emphasized that Germany and its partners had demonstrated amazing ability to produce seemingly adequate quantities and qualities of fuels, lubricants, and inflammables, despite meager crude-oil supplies. It seemed likely, therefore, that technical information available in Germany would help our military strategists.

During the fall of 1944, TAC canvassed the industry for competent technical men who might be made available for the oil studies abroad, and these men were offered to PAW for the purpose. However, there then developed an interest on the part of other Government agencies in sending missions of one kind or another to Europe. The net result was the loss of valuable time. Ultimately there was formed, under the Joint Chiefs of Staff, a Technical Industrial Intelligence Committee to supervise all missions seeking technical information in Europe. Director Snodgrass, of PAW's foreign refining division, was made chairman of the fuels and lubricants subcommittee of TIIC, and made arrangements for the briefing of the technical men who were selected for the mission.

By the end of February 1945, most of the members had gone to Europe on their assignments, and many of them had the unusual experience of advancing into enemy territory with the first waves of troops.

With the study underway, it then was necessary to reach specific decisions as to what should be done with reports and samples of materials sent back from Europe by the mission members.

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[18] Consisting of representatives of Fuels and Lubricants Branch of the Quartermaster General's Office, Foreign Economic Administration, Office of Strategic Services, and PAW.

Accordingly, Deputy Administrator Davis set up a special advisory group, headed by the TAC chairman.[19] Since the reports and other information at the time were classified as "confidential" or "secret," the advisory group members served as individual advisers to PAW and not as representatives of their companies, or as members of TAC. Their job was:

(1) To review reports received from the Technical Oil Mission and to recommend which reports, in whole or in part, should be released by PAW to units of the oil industry in furtherance of the war and of national security.

(2) To advise as to the proper handling of samples of materials sent back from the Technical Oil Mission, with particular reference to adequate analyses and evaluations.

The reports obtained by the mission from the field were sent to London for photostating or microfilming. Delays were inevitable under the stress of combat conditions, and restrictions were placed upon the information by the military, thus serving to retard its effective use by the special advisory group. PAW's primary objective was to identify and disseminate as rapidly as possible information of interest in the war program.

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[19] The TAC was of the greatest assistance in developing procedures and preparing the members through concise technical summaries of the processes known to be operating in Germany. The Enemy Oil Committee made available aerial photographs of the German plants, and the best evaluated intelligence data on their size and operation.

SELECTED MATERIALS ON THE CONTROLLED MATERIALS PLAN

(Excerpts from "Selected Readings on Energy Self-Sufficiency and the Controlled Materials Plan," prepared by the Environmental Policy Division, CRS, Library of Congress, for the Permanent Subcommittee on Investigations of the Senate Government Operations Committee, August 1974)

THE CONTROLLED MATERIALS PLAN

The most recent experience with allocation of materials to attain certain national goals in a time of emergency was that of the Korean War, using an adaptation of a materials management program used during World War II.

Korean War Experience.—Under national security production goals and authorities established by Congress in the Defense Production Act of 1950 (64 Stat. 798), the United States launched a three-year, three-pronged preparedness program which provided for sharply increased military production, increased defense production capacity, and expanded civilian industrial capacity to produce greatly increased quantities of steel, aluminum, petroleum and other essentials. With an investment of some $50 billion a year for three years, the country actually reached most of its goals on time. Among the many production achievements were expansion of petroleum output by 20 percent, electric power production by 40 percent and steel capacity by 18 million tons over pre-1950 levels.

World War II Experience.—During World War II overall U.S. productive capacity was increased to a level fully a third greater than it had been in 1939, through the crash emergency production effort called for by the war.

These two gigantic production achievements designed to meet national security goals were achieved only after several trial-and-error industrial mobilization efforts which finally evolved into a rigorously scheduled materials management production approach—the Controlled Materials Plan (CMP). The CMP approach required nationwide control over only a few strategic resources: steel, copper and aluminum. Scarce supplies of petroleum were closely coordinated with the CMP, but allocated through the Petroleum Administration for War during World War II and a similar agency during the Korean War.

These key materials were allocated according to overall national production priorities determined by quantitative production programs and goals as specific as those outlined in Project Independence. Authority to decide on scheduling and allocation in both cases was vested in a national production board which had responsibility for allocating these key materials for both defense and civilian use.

Several aspects of the Controlled Materials Plan should be kept in mind in any consideration of the contribution it might make to an energy development or materials production program:

First, the planned allocation of only a very few materials proved sufficient to attain the substantial goals of defense production on schedule. Steel, copper and aluminum were so widely used in World War II and the Korean War that they became themselves the simplest instrument for programing the use of many other industrial materials. They were the controlling as well as the controlled materials under the CMP.

Second, the CMP can be, as it was during 1950–53, an "open-end" materials allocation procedure, designed to assure completion of essential production with minimum interference with the rest of the economy.[4] Although specific information on both supply and demand for those few critical materials was requested from all supplier and user plants, controlled allocation of the materials was made only to those specific firms whose production capability had been enlisted for achievement of national priority goals and only for that portion of the supply needed for these goals. All industries, including the key industries under the Plan, were free to purchase remaining supplies of these and other materials in the "free" or "open" market.

Third, the CMP procedures were closely patterned after normal industrial practice. It was everyday practice in industry for the production manager to obtain data on product needs from top management and then to schedule production and order materials and parts to meet these schedules. He relied on his suppliers to make deliveries on time, or he got new suppliers. But, under conditions in which critical materials are in short supply, he could no longer rely on the competitive process to assure prompt delivery. Suppliers were oversold and the executive responsible for production could not plan ahead.

What CMP did, in effect, was to greatly reduce the procurement hazard as far as essential production was concerned. Under CMP, the Government solicited and established the supply need of management. The production executive followed normal practices and worked up schedules and materials requirements. When these schedules were approved he was assured of material and parts delivery. Prime consumers gathered the requirements information from their suppliers and in turn passed along materials allotments to their suppliers. CMP procedures took the fullest advantage of the existing lines of communication and authority in normal business practice. The everyday chain of customer-supplier relationships was used as far as possible.

One reason why the CMP was comparatively easy to apply during World War II and the Korean War was because in the United States both material consumption and end-item production are highly concentrated in comparatively few private companies. During the third quarter of 1942, for example, the 100 largest company consumers of each basic metal accounted for half or more of the consumption of each controlled item. Although the desirability of such concentration is a subject of serious current domestic concern and investigation, the existence of such company end-use concentration makes it possible to reinforce effective administration by intensive direction of the activities of large users, thereby minimizing the burden of control on small business and releasing governmental staff from inconsequential detail.

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[4] During World War II, this was not the case: The allocation of the total supply of the controlled materials was tightly managed under the overall War Production Board's mobilization and allocation authority, as were many other scarce materials through other allocation and supplier limitation schemes. Total control, however, is an optional, not essential feature of the CMP.

There were, of course, a number of industrial mobilization problem which remained unresolved even after two war-time experiences with national emergencies and the CMP. Chief among these was the failure to bring the Armed Forces' contracting authority within the national materials distribution control system responsible for executing the CMP.

Although the Armed Services were claimant agencies for scarce materials programed and allotted under the War Production Board's (WPB) authority, these services continued independently to place contracts for delivery of all types of war material without regard to the level of deliveries which could be supported by the quantities of scarce materials subsequently allocated to prime and subcontractors under the CMP. The power to contract is the power to set goals. Conflicting production levels were thereby implied which the WPB Chairman chose not to protest.

Despite these weaknesses, the production records under the CMP in both wartime emergencies were impressive. More to the point, they met our critical national production goals within the fixed time periods which the national emergencies required.

The experience with CMP might, therefore, not only identify problems likely to arise but also suggest pitfalls to avoid in any energy or materials policies and goals. With this in mind, it should be useful to examine CMP in reasonably close detail as the following selections do.

(12) "WARTIME PRODUCTION CONTROLS," BY DAVID NOVICK, MELVIN ANSHEN, AND W. C. TRUPPNER, COLUMBIA UNIVERSITY PRESS, NEW YORK, 1949. EXCERPTS ON: ARMED SERVICE CONTRACTING, CONCENTRATION IN PRODUCTION OF END ITEMS AND IN CONSUMPTION OF MATERIALS, ADMINISTRATIVES STATISTICS, GENERAL CONCLUSIONS.

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The placement of contracts is the force which sets the economic machine in motion. In "normal" times the desires of individuals as evidenced by their willingness to pay certain prices determines whether certain products are made and certain resources used. In wartime, reliance is placed on control in the form of priority, allocation, or some other method of direction. Nevertheless, the impact of procurement, the placing of a contract which requires certain materials, facilities, management, and labor, is still the primary force determining the rate of operation of the economic machine.

When a contract is let, certain forces are set in motion. Business attempts to carry out the terms of the obligation contracted for. To the extent that the required items are controlled, priority and other assistance is used. To the extent that the items are not controlled, they are procured in the normal way. When a contract is made, the manufacturer initiates his procurement by going as far as he can without priority assistance and by completing his procurement in the tighter items to the extent possible with priority assistance. He obtains some items up to the maximum of his needs without resort to priority. He obtains all that he needs of some other items by virtue of priority or allocation assistance. In a few cases even with maximum priority assistance he obtains either a smaller quantity of the items than he requires, or he gets his requirements at later dates than called or by his schedule.

It is important to recognize that the letting of the contract or the establishment of the schedule is the basic force which sets demand in motion. Once the contracts are let, review of the program can attempt only to give priority or allocation assistance to the most important segments of a demand which inevitably is in excess of supply for most production materials. Even when balance is created for one item through the allocation machinery, many other demands which can be satisfied without priority continue to be effective. This causes a dissipation of resources.

Throughout World War II we initiated priority, allocation, or programing to deal only with the items in tightest supply. Determinations of shortage were translated into administrative action only when critical needs were not being met. This meant that we were always "dividing up the shortages" rather than making plans which recognized that a program had to be cut, or that production of the short items had to be expanded in relation to a specific time schedule. Planning after a shortage exists can never be fully effective and is always wasteful of resources. If we had realized at the outset that resources would be short and that once procurement was initiated the drain on resources had been started, we would have adopted a procedure which would have made plans and programs effective before they were translated into actual procurement contracts. This would have established the control at the beginning of the operation rather than midway.

From 1940 to 1945, the civilian war agencies quite properly took the position that their staffs were not strategists and could not determine the number of tanks required as contrasted with the number of planes or battleships. They reserved for themselves only the function of determining whether the aggregate program could be given the economic assistance necessary for its execution. There is nothing wrong with this philosophy, since those who are trained in the art of war are best fitted to determine the types of weapons needed. On the other hand, since procurement was actually executed on the basis of plans as drawn, the machinery did not exist by means of which the civilian agency could shrink the procurement demand of the armed services to the actual measure of output that could be supplied by the economy.

A military contract mortgages production, facilities, material, and labor for months ahead. Once let, contracts establish a movement in the total economy which, if the original award is determined to have been out of line with subsequent policy, can be modified but cannot be changed. The civilian war agencies from 1940 to 1945 therefore were always in the unfortunate position of being presented with a reality, not a plan, If the reality called for 12 million tons of steel and the actual portion of supply that could be devoted to it was only 9 million tons, the civilian agency could limit the delivery of steel to 9 milllion tons, but it could not change the direction of indirect demands on men, materials, and facilities involved in the outstanding contracts for which 3 million tons of steel had not been provided.

The policy followed in the field of civilian procurement was of a related nature. Here, WPB took the position that it would not interfere with the commercial negotiation of contracts and would interject a control only when the effective fulfillment of an undirected civilian contract would work against the war needs for the same item. Conse quently, in addition to the military pressure on resources, there was non-military pressure in the form of purchase orders for items which could not be delivered within the framework of total military and war-related civilian requirements. In its development the Board did in some measure change this policy as applied to commercial procurement. It finally said that certain products could not be made, and that other items could not be made or delivered except against specified types of priorities or allocations. By the time the war ended, unwarranted commercial orders could no longer be placed in the more critical areas. Unfilled military orders continued to the very end, however, and no real effort was ever made to control them.

To be fully effective any plan requires adequate knowledge and control at every stage of its development. It is important, therefore, that the procurement control experience of World War I, forgotten in World War II, be made a part of the authority of the agency charged with responsibility for future industrial mobilization. This means that the new agency at all times must have responsibility for reviewing the totality of military programs to determine their economic feasibility, and that before the military are permitted to engage in procurement there must be a specific determination of the extent to which all or a part of the program can be fulfilled by the nation's resources. If any cuts must be made, the curtailment in demand should be incorporated by the military in the form of revised procurement plans so that there is no award of contracts which result in an artificial pressure on the country's resources. In summary, it is hardly too much to say that the power to place contracts is the most important force in determining the pattern of industrial mobilization. When this force is not integrated with material, product, and labor controls, conflict and friction can be anticipated as one of the more important results. Since the actions associated with military procurement preceded the imposition of material and other controls during the war, the civilian agencies were constantly in the position of a fire department trying to put out a series of conflagrations with an inadequate supply of water.

Since there are different types of shortages, we also should have learned that all economic demands must be evaluated at the same time. At the outset of World War II, the greatest shortage was in facilities—the buildings and machines needed to make weapons. When this shortage was alleviated by the construction of new plants or the conversion of old ones, an acute shortage of materials developed as the new facilities added their chew-up to that of the existing plants. Just as 1942 marked the transition from facility to material shortages, so 1943 saw a shift from material to component shortages. The component shortage was in large measure a management problem. A substantial part of the responsibility was the failure of the planning agencies to evaluate their component requirements. Nevertheless, particularly in such industries as bearings, management refused to make the required adjustments even when apprised of critical needs. By mid-1944 the worst of the component shortages had been resolved and the major problem became manpower. As soon as one shortage factor in the production equation was corrected, another was created. This indicates rather clearly that just as an individual company must plan its operations with adequate recognition of facility, material, component, labor, and management requirements, so an over-all economic effort can be carried out only with adequate evaluation of the importance of each of these elements in the summary of total production requirements.

The heart of the control problem is in the contracting function. Demonstration of this prime fact probably is the most important single lesson to be learned from a review of the administration of wartime industrial mobilization.

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The impress of these major operating lessons is clear in the War Production Board's record of experience.

(1) The power to contract is the power to control, and recognition of this economic force should be reflected by lodging clearance authority for at least the substantial contracts in the responsible civilian war agency.

(2) The most effective controls are simple, adapted to existing industrial procedures and records, and call for a large measure of business cooperation with and understanding of the announced objectives.

(3) Attempts to limit the impact of a control by compromising its maximum operating requirements tend to foster a step-by-step expansion which lags behind real needs.

(4) Material allocation methods must be correlated with respect to both broad programs and individual plants.

(5) Concentration of industrial production and material consumption makes it possible to reinforce effective administration by intensive direction of the activities of large users, thereby minimizing the burden of control on small business and releasing the agency staff from inconsequential detail.

(6) All control systems benefit from continual reappraisal based on the application in public business of the accounting and administrative statistics techniques which are prime management tools in private business.

More important than any conclusions drawn from the daily operating record of the War Production Board, however, is the lesson driven home in two wars that national preparedness is an industrial and civilian as well as a military responsibility. No nation is armed for its own protection until it is prepared in any emergency with a plan and an operating program for integrating the individualistic industrial economy into a unified mechanism under national control.

The armed forces in being must stand the first shock. But they are a puny defense unless the industrial strength of the country can be swiftly organized to back them up and equip the expanding military establishment.

Blueprints of organization and over-all policies are the first step. They are not adequate in themselves, however. The organization will not function without trained, experienced personnel, and the policies will not be executed without efficient administrative techniques. It is through the combination of these factors that national preparedness finds the backing in the industrial economy for the fleet which guards the sea lanes, the planes which patrol the skies, and the ground troops which are the defensive shock force and the nucleus of the emergency expansion. The United Nations may in time remove the causes of war or, by police action, prevent its outbreak. If this fails, atomic fission may so change the character of war as to make defense impossible. In the intervening period, however, as long as world security and national preparedness demand the maintenance of an American Army, Navy, and Air Force, it would be a criminal omission to fail to support them with the nucleus organization and the machinery for rational, swift industrial mobilization for military production, which is the real source of strength of the armed forces. The experience of two wars clearly marks the course which future policy should follow.

(5) FOWLER, HENRY H., "OPERATING UNDER CMP: PROBLEMS AHEAD IN PRODUCTION", MANUFACTURING MANAGEMENT SERIES: NUMBER 199, AMERICAN MANAGEMENT ASSOCIATION, INC., 1952. A PAPER PRESENTED AT THE PRODUCTION CONFERENCE, CHICAGO, NOVEMBER 8–9, 1951.

84

Problems Ahead in Production

¶ Henry H. Fowler

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THE present defense program to make our nation strong and secure must have the full understanding and solid support of the American business community, if it is to succeed and endure. On behalf of the National Production Authority, I bespeak again, as in World War I and World War II, a spirit of teamwork between government and business, based on a common understanding and undertaking of a job assignment —for that is what defense production is.

I should like to indicate at the outset that two months ago I was a private citizen; and, upon completion of my term, I expect to return to private life next summer. Therefore, the picture this paper will give you is not one of the completely informed public servant. After all, it is too much to expect one to learn all of the angles of this very difficult problem and to gain a very wide perspective in two months. I want you to feel, frankly, that I have not a single axe to grind—I want you to feel that you are going to get the picture as you yourself would see it if you had been on this job for two months.

Now, in this perspective, I think you will want to get from me not details but an over-all look at the defense program—where we stand and where we are going. However, before we take that look into the future, let us consider how we got here and why.

PURPOSES OF THE DEFENSE PRODUCTION PROGRAM

The origin and purpose of the defense production program is sometimes forgotten, as the complexity and confusion of grappling with daily problems oppress us. We are embarked, as you know, on a program to

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achieve peace and security through sacrifice and renewed strength. What are the circumstances that gave us a sense of unity, common purpose, and direction in the present defense mobilization effort? Simply this: Our nation is in deadly peril. Our homes, our way of life are literally in danger, and we face an international enemy that is bent on our destruction —an enemy that is constantly growing in power.

The maintenance of peace—or, in any event, our ultimate survival in case of war—depends upon our matching that power with an even greater power of our own. And the blunt fact is—and this is what is hard for us to accept—that peace and survival depend not only on matching that power, but sustaining, over the long-term future, an adequate level of military strength and industrial preparedness, with all that it costs and all the dislocation that is involved. Only a sustained strength over a period of time will enable us to regain the strategic initiative that was abandoned in 1945 with the complete and trusting demobilization. Only a steady and persistent use of a regained strategic initiative for many years can break the will of the Soviet masters to world conquest, either by domination or aggression.

It is only a realization and an acceptance of that basic premise which give sense to this defense production program. If you reject the premises I have just stated, the whole program is meaningless. In any event, Congress accepted the premise in 1950 when it enacted the Defense Production Act; and the Congress stated it very simply in the preamble, saying: "The United States is determined to develop and maintain whatever military and economic strength is found necessary to carry out the purpose."

We did not expect to achieve this goal of preparedness without cost. The people in the United States, speaking through the Congress, recognized at the very outset that it would entail dislocation, sacrifice, and difficulties for American manufacturers, distributors and consumers, and the laboring man. Our Congress said: "Under these present circumstances, this task requires diversion of certain materials and facilities from civilian use to military and related purposes."

A THREE-PRONGED PROGRAM

The three-pronged plan that was adopted was a bold and simple one. First the plan provided for sharply increased production of military end products, primarily aircraft, tank-automotive, and ordnance.

Second, Congress recognized that it was not enough just to increase the production for current use of military end products. It recognized that a defense construction program—a facility program—was also desirable to provide increased war-making capacity. That program had two facets: Additional production lines for the current military end product production, plus a stand-by capacity for the rapid equipping of an M-Day force in the event of total war. Thus the shape up in the first year of a total war could be accomplished at a very rapid rate.

Third, provisions were made to expand industrial capacity to produce the basic materials that modern armament requires in large quantities. The only course to immediate and continuing preparedness, without indefinitely enduring detailed controls that accompany total war, is to pay a sharp price now to secure increased quantities of steel, aluminum, chemicals, electric power, petroleum, and the like. Only in that way can a dual economy, with a strong military setup and a pre-Korean civilian standard of living, be carried forward without the permanent machinery of extensive priorities and allocations. In so outlining this dual objective of the Defense Production Program, Congress said: "In order that this diversion and expansion may proceed at once and that the national economy may be maintained with the maximum effectiveness and the least hardship, normal civilian production and purchases must be curtailed and redirected."

Sometimes it is comforting for us in the NPA to realize that curtailment and diversion were not concepts invented by bureaucrats to harass the citizenry. Congress is really responsible. Even Congressmen forget this from time to time and mislay somehow the fact that they coined the words and cranked the engine. However, the legislators wisely responded to the inescapable necessities of national security.

PROGRESS IN DEFENSE PRODUCTION

Where do we stand today in the execution of this three-pronged program? To execute the plan a three-year program costing $50 billion a year was undertaken. That program now, a year later, is far beyond the blueprint stage and well through the preliminaries of mass production. The terrifying momentum of American industrial power is gathering force once again and making itself felt throughout the world. It is today the largest single factor for peace and security.

1. *Production of Military Goods*

Deliveries in military goods, during the third quarter of 1951 were estimated at a total of more than $5 billion. That was one-third more than the previous quarter, and about four times the rate for 1950.

However, deliveries are misleading as a measure of the total effort. Counting all the goods-in-process—that is, the oil that is still in the pipeline, the planes that are almost completed, etc.,—Charles E. Wilson estimates that during the third quarter of 1951 we were using materials for military goods at a rate of nearly $8 billion per quarter, or at an annual rate of $32 billion. By the end of the second year, if the present momentum continues, it should reach $10 or $11 billion a quarter in deliveries, or at a peak rate approaching $50 billion per annum. From these figures, you can make your own estimates as to the way this curve is going to continue to go up for a few quarters and then, in terms of the present program, hit a plateau.

2. *Defense Facility Expansion*

We have underway, in response to the second part of the program, a defense facility expansion for military equipment. By the end of 1953 this program will give us a national stand-by capacity to produce, if the need should arise, 50,000 planes a year, 35,000 tanks a year, and 18,000 jet engines a month, together with expanded levels of all the other auxiliary products which are necessary for a holding operation in the first year of a total war.

3. *Expansion of Industrial Capacity*

Finally, and as a very important and integral part of this three-pronged program, we have already reached the half-way mark on the program to expand our industrial capacity for vital war-making resources. I would like to cite just a few illustrations, at the risk of boring you with figures that may be forgotten.

We will increase our steel capacity under this program by approximately 18 million tons over the pre-Korea level. This increase is nearly equal to the installed capacity for steel-making in Great Britain. We will double our aluminum capacity, increase copper production by 20 per cent, increase magnesium output eightfold, and double our molybdenum output.

The increase in aluminum capacity will be equivalent to over 400 per cent of the capacity existing in 1939. We will increase our electric-power production by 40 per cent, an amount equal to the total increase in generating power in the 57 years ending in 1939.

Industry and defense run on oil and, therefore, we plan to expand our petroleum output by about 20 per cent. If metals are the skeleton and oil the lifeblood of the economy, then chemicals make up much of its flesh and sinew. We will increase the supply of many chemicals as much as 50 per cent over present usage. We plan to boost our sulphur production by 15 per cent (we now produce over 90 per cent of the world supply). Ammonia and other nitrogen compounds used in explosives, plastics, and so on, will be expanded by about 30 per cent. There will be a 40 per cent increase in the production of benzene, which is used in synthetic rubber and plastics and the manufacture of aniline and phenol, and a 50 per cent increase in chlorine, to name just a few.

In the crucial machine-tool field we will double and redouble our present rate of output. It was estimated that approximately $3 billion worth of that equipment would be needed during 1951 and 1952 alone.

These are a few examples to illustrate the magnitude of this basic industrial-expansion effort. Of considerable significance to private management is the fact that this great expansion has been carried forward by private enterprise. It has been induced to a large extent by the tax-amortization advantage but, nevertheless, the facilities are owned and operated by private enterprise.

THE CONTROLLED MATERIALS PLAN

This three-pronged effort has placed the greatest demand upon the ability and the resources of the United States that it has ever experienced except during the period of total war in World War II.

In the last quarter of 1951 and more particularly in the first quarter of 1952, we are able to see, for the first time, that we are getting something for our money. The insurance policy has been bought—the diversion from normal civilian production that was contemplated right at the outset of the program is here, and it is a painful but comforting reality. In order to engineer this vast diversion on a rational scale that would deliver the right quantities and the right types of material at the right time for defense purposes, and still assure (and this is often overlooked) the delivery of a smaller but nonetheless definite amount to a wide variety of civilian uses, the Controlled Materials Plan, covering steel, copper, and aluminum forms and shapes, was instituted in July, 1951.

Requirements for Military End Products

The magnitude of the diversion, in terms of these controlled materials, is a fairly good bench-mark of what has been happening. The direct military requirements in the first quarter of 1952 for what we call the "A" products require 40 per cent of the nation's aluminum, including about two-thirds of the primary aluminum. In the field of copper, direct military requirements in the first quarter are taking over 40 per cent of the brass mill product. The direct take from steel production is about 20 per cent.

However, the A products tell only half the story of what materials are going to defense. That again is a fact which is very often overlooked by those who say that we do not need a Controlled Materials Plan—who claim that there is so little going to the military, that materials can be handled through priorities. These percentages which I have quoted do not include the materials taken from normal civilian channels for the defense construction program (as distinct from the military end product)—the addition of new production lines for military goods and the expansion of our industrial capacity.

For example, reliable estimates are that the sum total of the three-pronged defense program demands are from 40 per cent to 50 per cent of all steel production, when you take into account the drawoff for the A-products and the drawoff for the defense construction program.

Allotments for Consumer Goods

The harsh impact of these diversions is upon us. Many producers who depend basically upon copper and aluminum will receive their 4B first-quarter allotments at very low levels, in relation to pre-Korean use. The example that is most significant is that producers of the consumer-type items, of the so-called less essential type, will receive roughly 50 per cent of the steel used for their pre-Korean production—provided the steel is not in more critical forms and shapes; 20 per cent of their base period use of aluminum; and 10 per cent of their base period use of copper. The more essential categories of civilian-type products will receive similar allotments of steel, but substantially higher percentages of copper and aluminum.

For many of these producers there will be a sharp realization that the defense program is really rolling. For some, their share will give them just a fighting chance for survival. This is a tragic overtone of our current defense program, though not as tragic, of course, as the death or wounding of our boys in Korea. It is very difficult for us, particularly in the NPA, who are in day-to-day contact with this problem, to receive the pleas for just a little bit more material and know that the arithmetic of the situation just does not permit it.

These varied pleas sometimes have tragic-comic overtones. For example Manly Fleischmann likes to tell the story about the toy-train manufacturer who came in for more material. After a long, well thought-out, and ably-prepared presentation as to why he was entitled to more, he finally climaxed his plea with this statement: "Well, Mr. Fleischmann, it all boils down to this—you're either for kids, or you're against them."

Severe Shortages of Metals

This distress over the first quarter of CMP allotments will not be limited to the producers of consumer-type items alone. Every company which appealed to the 20 claimant agencies and the 34 industry-division directors in the NPA was unhappy with its fourth-quarter allotments for

1951. The screened or rock-bottom "we-have-to-have-it" demands in the various claimant agencies for the first quarter of 1952 for carbon steel—that is, when all the demands are totaled—adds up to 150 per cent of the supply. For structural steel, the demand is 205 per cent of the supply. The demand for copper and aluminum varied somewhere between 170 and 180 per cent. In these simple percentages you have the reason for a Controlled Materials Plan.

We should not forget in passing the so-called minor metals, of which the shortages are even more severe—nickel, platinum, tungsten, tin, columbium, cobalt, and selenium. They are much in demand for military products, and in some cases the total supply must be diverted from civilian use. This is, of course, creating serious problems for producers who depend on them. There are also shortages of other materials such as chemicals and a variety of other items.

SUPPLEMENTARY PROGRAMS

In addition to CMP and the traditional priority regulations, we have a series of so-called "M" Orders, 88 in number, which specify rules for placing, accepting, and scheduling defense orders, and in some cases limit the amounts of the materials for use in non-defense production.

A special program has been developed for increasing supplies of machine-tools, the so-called "Pool Order," for stimulating all-out production by the machine-tool producers. In addition to this device, there is a very vigorous effort to promote subcontracting by the major machine-tool producers to manufacturers of machinery and others who have the facilities and know-how adaptable to that purpose.

Finally, there is an order which provides for a temporary but very rigid control on the distribution of new tools and new civilian-goods models and deferral of modernization which can be passed up for a period of time.

THE PROBLEMS AHEAD

Thus far, I have provided a rough summary of the picture as we stand today. Now, what of the future? Predicting future developments is a difficult and dangerous task for any individual who has a public responsibility, and I would much prefer just to give a recital of the recorded facts and leave it up to you to draw your own inferences about the future. However, I will attempt to state briefly some of the basic problems ahead which I think merit your attention, with the very necessary caveat that any individual's conjecture about the shape of things to come should be discounted as such. Also I want to assume, for purposes of this discussion of the future, that the period just ahead is not one which will be marked by a total war. That event would change the entire outlook so sharply overnight that it would set in motion a completely new series of developments.

There are two problems that I will not discuss because I do not feel qualified to do so. One is the question of manpower as a possible impediment to defense production: production in so-called critical labor areas, where the situation is very tight; production in certain lines and types of manufacture where special skills are required that far outstrip that which is available in the normal sixty-to-ninety-day training period. I simply am not qualified to appraise this subject.

The other problem that it profits little to conjecture about here is a very real one: the likelihood that during the year ahead there will be requested some new levels of military production that are not now a part of the picture. Those requests are bound to collide with the feeling among many in Congress, and throughout the country, that we are approaching a point in this dual economy at which some limitation must be made on the extent of drawoff for military and defense purposes; otherwise, if additional new programs are authorized, the drawoff would be such that the dual-economy objective would be placed in limbo.

I cannot pass judgment, and would not attempt to do so, on how that very important but very delicate question of a balance between new military programs on top of existing ones, and the maintenance of the civilian economy, will be decided. This I know: It will be decided in the Congress of the United States, and it will be decided, of course, in terms of appropriations authorization for new programs.

Overcoming Materials Shortages

Now, I will address myself briefly to a few of the major problems that we do definitely see ahead. The first one is, of course, an aggressive execution of a rounded program to minimize the extent and the duration of materials shortages. The best and only satisfactory solution to materials shortage in a free society is increased production and supply, so that we can overcome the shortage and get rid of the controls. And, as indicated, this is greatly emphasized in the defense program. Hence every effort in 1952 will be made to keep these expansion programs for basic materials on schedule and moving ahead. That is bound to involve, in my judgment, a more intensive project scheduling and a more intensive effort to expedite the flow of equipment to these expansion projects than we have witnessed previously.

It is inevitable that conflict between expansion programs of almost equal urgency will arise. We found out in World War II that sometimes it was just as unwise to attempt to do everything all at once as it was to do too little too late. A wise resolution or minimization of these inevitable conflicts calls for, as I have indicated, detailed project scheduling and equipment-delivery controls of a more intensive character than have been undertaken thus far. Already, for example, it was necessary to hold back the expansion of the steel and chemicals programs. There was a lack of structural steel because the right-of-way was given 100 per cent to other programs such as aluminum and some of the military facilities. In the first and succeeding quarters of 1952 we will try to make up for that temporary setback to the steel program so that it may be pulled back to schedule.

The Equipment Bottleneck

As we get through the structural steel bottleneck, we are bound to encounter new bottlenecks in the form of competing demands for heavy equipment that is necessary to mass production—cranes, electrical machines, gear and control equipment, large pumps and valves, etc. You just cannot have two much-needed plants, requiring two cranes, both failing to go into production because each one is going to receive one crane. We cannot really abide that situation; and, therefore, the competition for them will require considerable scheduling and direction of delivery. The same is true for many of the smaller items, or common components, as they are called.

This situation may get so acute that the devices that are at hand to deal with it will not be effective in meeting schedules, and we may require some decisions of timing that will tend to phase out certain of these construction programs over a longer period than the three years originally contemplated, pushing the ultimate completion of some of them over into 1954.

This situation is certain to result in a very careful screening of new construction starts and modernization programs that are unrelated to defense. We will have to try to ascertain which of those new proposed construction starts and modernization programs can be deferred. Conversely, we must give the right-of-way to certain programs that must be added in order to complement construction programs already under way. For example, we must have increased supplies of certain chemicals and auxiliary materials to match the expansion of aluminum and steel.

Even new military facilities may be halted before they are begun lest they compound the construction bottleneck, if substitute facilities can be found from those that are available because of the curtailment of civilian products.

Maximum Production from Existing Sources

The next big effort to meet this materials situation is, of course, to maximize production from existing sources. That means a greatly increased emphasis from all government levels on averting work stoppages and related factors that seriously interfere with the production of needed materials. You have heard a great deal about work stoppages that affect direct military products. You will hear more about them as they may affect the flow of these critical materials.

A second phase of promoting maximum productivity from existing sources is naturally the promotion of increased worker and management efficiency—the kind of problems that are constantly before you. Whether we will have to go to anything as formal as some of the old wartime devices, such as the labor-management plant committees, and whether we will have to use some highly selective price and tax incentives to induce the maximum output (provided they do not unduly disrupt the stabilization program) are questions, at least, that will have to be considered.

Developing New Materials

Of course, there will be one phase of the materials-shortage problem that will not be licked in 1952 and 1953: that is the problem of minor metals, and the one major metal, copper. It will be 1953 or 1954 before the fruits of our expansion and exploration program in that area can be realized. One notable exception in that regard is the so-called Nicaro program in Cuba, which will bring in additional nickel supply early next year to add 10 per cent to the free world's supply of that very valuable metal.

Mr. Wilson has recently urged, through the medium of the World Metallurgical Congress, that American metallurgists and their colleagues in other lands put their skill and energy into the hunt for the finding and development of new materials. There is now an agency in Washington called the Defense Materials Procurement Administration. This is an independent agency which was set up for the single purpose of expanding the supplies of the materials that we need from overseas and domestic sources in the so-called minor metals category.

Substituting for Critical Metals

In the meantime, we can get some relief from the shortages of these metals in 1952 and 1953 by substituting less critical materials, and through standardization and simplification, which may achieve substantial savings. I should register a caution at this point concerning the use of the defense program to achieve standardization and simplification. Except where the interference with free competition that is entailed is more than compensated for by very substantial savings of the vital short-supply material in question, we do not intend to use the Defense Production Program as a vehicle for standardization and simplification. On the other hand, if a substantial saving of a critical material can be achieved, we want very much to get the standardization and simplification entailed.

The invigoration of substitution as a way out is an area of almost unlimited challenge to the ingenuity and inventiveness of American research, design, and production engineers, as well as the management personnel that directs their efforts. For example, the very dark prospects of any complete relief from the copper situation as long as there is a high level of economic activity in the free world, would suggest, and often induces, the development of aluminum as a substitute, provided the timing is such that the development and utilization coincide with the increased supply of aluminum that may be expected during the next two years.

The Battle for Scrap

Lastly, as a means of minimizing the duration and impact of this materials shortage, is the battle for scrap. It may well be that our ability during the next six months, to capture for industrial use the ferrous and non-ferrous metal that is above the ground, may be of more significance than the extraction of new sources yet underground. It is the next six months that are the real crucial period in this current program. The utilization of scrap is a job of promotion and organization that will require all the finesse of American management—outside the government. I venture without fear of contradiction that "scrap" is a word to conjure with in 1952.

Balancing Allotments

There is one problem in connection with the achievement of a better-balanced allotment that is a serious one for 1952, and it is a rather new one. It has a certain element of menace and strangeness to it about which the men in the Defense Production Administration are peculiarly sensitive. It does not affect us so much in the NPA, since we are really a claimant agency for American industry.

The problem arises out of the natural and inescapable development of pressure groups who, believing quite humanly in the rightness of their position, are not content to exhaust the administrative processes of appeal or determination through their claimant agencies which are provided by the DPA, but seek to go outside that framework.

The responsible authorities in DPA expect to submit their determinations, with an explanation of the general rationale behind them, to the responsible committees of Congress, notably the Joint Defense Production Committee. Sometimes a special Congressional committee, quite properly interested in a special sector of the economy, such as transportation, agriculture, education, power and natural resources, inquires into the basis of allocation for a particular use. That is as it should be. It conforms to the traditional pattern of our Constitutional system: the separation of the powers, in which public officials in the Executive have to account for their activities to the appropriate committees of Congress. However, there is a tendency in some quarters to assume that the priorities' power and the allocations' power is divisible and can be exercised in defiance of the laws of arithmetic that make two and two equal four—that somehow, if Congress determines a particular allocation, we can make two and two equal eight.

Any resort in the year 1952—or at any other time—to legislative allocation in piecemeal fashion, without reference to the whole, is bound to lead to a breakdown in the allocation system, which has proved reasonably satisfactory through two wars.

These observations are in no sense intended to suggest that determinations on the Controlled Materials Plan should be free from close scrutiny by Congress or its committees. That is a valuable part of the process. But I am suggesting that to carry that process to the point of invoking piecemeal legislative allocation to special interests—be it highways, schools, ships, railways, or any one of the other 54 identifiable claims—is a very dangerous practice. I hope that it is a problem that we will not have in 1952, but it is one that we must watch for.

Production-Scheduling Techniques

I think you are entitled to know some of our current thinking about expediting the production and delivery of components through the so-called production-scheduling techniques.

Of course, the most obvious and complete solution to a shortage in components is to schedule, in minute detail, the manufacturer's deliveries—to go through his order book and make certain that no customer receives delivery before he needs it, that he gets no more than he actually needs, and that the flow goes to those who need it most. However, our past experience tells us that we should not resort to that particular method until we have exhausted the other methods, such as increasing the total supply of the component by a better-balanced and increased flow of materials to the component manufacturer and an intensive use of his facilities, or reducing, in general terms, the flow of the component to non-defense uses.

However, if we find that those avenues have failed, our division must resort, in the case of a component shortages which are blocking critical programs, to the order-book scheduling. We hope to be able to limit that to the smallest number of products.

Correlating Allocations and Distributions

There will be considerable difficulty in 1952 in correlating the allocation of the auxiliary materials to the controlled materials, as CMP really begins to work.

There will be great emphasis on the struggle to save small industry by channeling material to small producers who use copper and aluminum as a base material, and whose product is in the less essential category. The Small Defense Plant Administration will be a new factor in that field.

Then there will be an increased emphasis on programming civilian requirements and promoting equitable distribution of civilian-type products. We do not expect rationing. We think there is a good supply of most products on the shelves. The shortage of certain spot items creates real havoc in the civilian economy. We have to watch for those shortages and see that there is an increase in supplies by changing levels of special allocation where shortages will be crucial.

There will be an increasing correlation of our national defense production effort with that of the so-called NATO countries. The presence of General Eisenhower here, and the visit of Mr. Fleischmann abroad, recall the work of the combined boards in World War II. That is one of the most difficult and important problems we face.

There will be instances in 1952 where items no longer in short supply will be decontrolled. I can assure you that Mr. Wilson, Mr. Fleischmann and all of us will be vigilant in our attempts to isolate those particular cases and not continue a control when it has outlived its usefulness. We do not intend to let the arteries harden and just keep the controls because we have them installed.

The Need for Able Administrators

A very real problem is that of management. I am only going to touch on that by quoting from John J. Corson in an article in the *New York Times* in August, 1951, which was entitled, "Needed: A Civilian Reserve Corps," in which Mr. Corson said: "No group has a greater stake than the American business community in making the wisest efforts and use of our national resources to meet the world emergency. It is a curious paradox which prides itself on the wealth of its business talents but cannot meet the Government's request for a few hundred first-rate administrators."

Achieving National Equilibrium

Finally, the most important problem of all which we face not only in 1952, but in 1953 and the years ahead, is the problem of somehow achieving a national equilibrium and a national balance in this world situation. I cannot overemphasize the importance of achieving this balance.

A recent commentator has said of the Soviets: "Their analysis of our society, the free society of the United States, reveals us as the permanent prisoners of a chronically aimless momentum, possessed of enough brute force to grasp the strategic initiative at the climax of a crisis, but always doomed to forfeit it thereafter." That is what they think of us. The next few years may test our national character as it has never been tested before in any historic emergency, to determine whether or not we are really ripe for the position of world leadership which fate has thrust upon us.

The first test of that ability to achieve balance and equilibrium is in the long period of partial mobilization that may be ahead. Should there be a truce in Korea, or should there be promising signs of a new accord or a new settlement in the world, there will be a grave temptation to forego once again the economic sacrifices of preparedness and national security, and go back to the good old days of 1945, 1946, and 1947. Should the dove of peace flutter at the window at a time when the defense production effort is straining our economy to the utmost, it will take a wise and mature nation to hold firm and wait in grim readiness to see whether or not the aggressor has really changed his spots.

Let us suppose there is not a total war, that the period of the twilight relationship between the U. S. and the Soviets, in which we maintain our armed strength and partial mobilization, might last ten or 20 years. We shall reach the peak of our strength in the three years set by our program—that is, sometime in 1953. By that time, the defense construction program will be largely completed and the stocks of essential weapons will be high. It will be hoped that their quality will be improved and the quantity adequate to any threat. There will be new and terrible weapons that we shall constantly hear about. Under these circumstances, with our increased supplies of basic materials, we could then hope to return to civilian production, relatively free from controls, equalling and in some respects perhaps exceeding the standard of living we enjoyed just before Korea. Under those circumstances, there is no reason why we could not maintain the military strength required over as long a period as necessary.

Under these circumstances, the initiative for peace and the preservation of a free world would be ours. Can we face up to that challenge of the future and maintain in the years ahead the firm resolution that will be required to carry through to peace or security? That is the fundamental problem of 1952 and 1953.

(6) U.S. DEPARTMENT OF COMMERCE, "THE ABC'S OF THE CMP", A PAMPHLET PROVIDING BACKGROUND INFORMATION ON THE PRINCIPLES AND OPERATING PROCEDURES OF THE CMP AS ADOPTED BY THE NATIONAL PRODUCTION AUTHORITY DURING 1951–1953. U.S. GPO, 1951.

"ABC'S OF CMP: An Outline of the Principles
and Procedures of the Controlled Materials Plan,"
Department of Commerce, National Production
Authority, 1951

This booklet is intended to serve as background information and a short refresher course in the principles and operating procedures of the Controlled Materials Plan. Copies of the complete regulations, and detailed operating instructions for those directly affected by CMP, will be available from NPA in Washington or the nearest Field Office of the Department of Commerce.

Contents

1. CMP and the Defense Program.
2. CMP Defined.
3. CMP Fundamentals.
4. The Government's Role in CMP.
5. Industry's Role in CMP.
6. CMP Product Classification.
7. Scope of the CMP Program.
8. CMP in Operation.
9. Principal Regulations.
10. CMP Definitions.
11. NPA Industry Divisions.
12. CMP Materials.

1

CMP AND THE DEFENSE PROGRAM

Beginning with the third quarter of the year, effective July 1, 1951, the Controlled Materials Plan goes into operation. This plan—popularly known as CMP—has been adopted by the National Production Authority to deal with the problems of a dual economy. The purpose of CMP is to assure a balanced flow of essential production and construction with a minimum of interference to the civilian economy.

Defense production is moving into high gear, and while the overall impact on our economy is not as great as in World War II, the real impact on key materials, parts, and components is proportionately much greater.

A priority system is not adequate to insure that essential production and construction are completed on schedule. Production is a continuous process; all the parts and components of a tank must be produced and be on hand when needed, or we waste productive effort and jeopardize our defense.

Accordingly, CMP has been adopted as the best method to assure that our efforts are in balance and undelayed. CMP ensures that materials and components are available for defense and for defense-supporting projects.

Furthermore, CMP provides the facts and figures on supply and demand of key materials and components that make it possible to strike a better balance between demand and supply of controlled materials for non-defense uses.

With CMP it is possible to determine materials needs, and to program essential production and allocate the required materials. It is then possible to measure the balance of key materials remaining for nonprogrammed production and to employ other NPA controls, such as (limitations) orders, to effect a measure of balance between nondefense demand and the remaining supply.

While CMP poses the problems of a great deal of paper work, those in industry who will carry the burden of this paper work are generally in favor of the plan. It will take time for the plan to reach a smooth level of operation (based on World War II experience the first quarter under CMP is largely a fact-gathering and testing period). But once underway it assures our defense needs, and if the international situation should require an all-out effort, CMP will already be in operation. And past experience tells us that CMP is the only possible plan for a large program of military production.

2

CMP DEFINED

To get a clear picture of the Controlled Materials Plan, it is important, first, to make a distinction between CMP and other production and materials controls that are used in a period of high defense or war production and which are again becoming bywords in the language of the business executive.

CMP is not a priority system which only provides a first crack at available materials and components; and it is not in itself a plan to limit production or curtail the consumption of critical materials.

Other controls, such as priorities or limitations, will be used to supplement CMP. But CMP itself is an *affirmative method for scheduling production of defense and defense-supporting items, in the light of materials supply, and for allotting the basic materials to assure completion of that production.* CMP doesn't give a hunting license (priority) for materials; it gives a certified allotment. And CMP doesn't seek to restrict production; it schedules and guarantees essential production. CMP doesn't tell the manufacturer what he can't do—it tells him what he can produce and what he is expected to produce. (See Secs. 4 and 5 for procedures.)

3

CMP FUNDAMENTALS

The Controlled Materials Plan depends on three fundamental ingredients:

1. An accurate and workable "yardstick" to measure essential production needs against materials supply, and to provide

a common control for programing production and the use of materials. Under CMP, this common "yardstick" is found in three basic metals—steel, copper, and aluminum. These are not only the most widely used materials in defense production, which therefore must be controlled and allocated; they are so widely used that they become, in themselves, the simplest instrument for programing and controlling the use of many other scarce materials. They are the *controlling* materials as well as the controlled materials.

2. CMP demands accurate information as to the need for, and the supply of, these "yardstick" materials, both as to total tonnage and as to specific shapes and forms. Here again, the controlled materials—steel, copper, and aluminum—can be measured accurately back to the mill and foundry. In effect, military and defense-supporting needs are translated into amounts and shapes of steel, copper, and aluminum required. This is the basis for determining authorized programs and for establishing a supply-demand balance in the unauthorized area.

3. Finally, CMP requires a procedure that provides for the establishment of production needs, the approval of production schedules, and the allotment of materials with a minimum of supervision and paper work.

To meet this requirement, CMP procedures—both in concept and in fact—are closely patterned after normal industrial practice.

It is everyday practice in industry for the production manager to obtain data on product needs from top management and then to schedule production and order materials and parts to meet these schedules. He relies on his suppliers to make deliveries on time, or he gets new suppliers. But, under present conditions, he can no longer rely on the competitive process to assure prompt delivery. Suppliers are oversold; the executive responsible for production can no longer plan ahead; delays and waste are inevitable.

What CMP does, in effect, is to eliminate the procurement hazard as far as essential production and construction are concerned.

Under CMP in the broad sense, the Government establishes the need of top management. The production executive follows normal practice and works up schedules and materials requirements, and when these schedules are approved by Government, he can be sure of delivery of his materials and parts. Essential production can be programmed and planned efficiently, and a smooth and balanced flow of defense-supporting products assured.

4

THE GOVERNMENT'S ROLE IN CMP

To make the Controlled Materials Plan work smoothly, government and business cooperation is essential—each has its part to play.

The basic role of Government is to establish the over-all needs of the country for essential products and facilities, to balance these needs against the supply of key materials, and to authorize producers in industry to go ahead on production with a guarantee of the necessary materials.

In broad terms, here is how this responsibility is divided among the several government agencies:

1. Government determines the supply of steel, copper, aluminum, and other basic materials. Supply information is gathered and continuously reviewed by the appropriate NPA Industry Divisions.

2. Government determines the need for defense and defense supporting production and construction. This is the responsibility of the claimant agencies, which include: The Defense Department, the NPA Program Bureau and Industry Divisions, and others like the Atomic Energy Commission, the Defense Transportation Agency, and the Petroleum Administration for Defense. These needs are presented to the Program Bureau of Defense Production Administration by the claimant agencies.

3. Government reviews requirements in the light of materials supply, balances out requirements conflicts, and then authorizes production programs and makes appropriate allotments of controlled materials to the claimant agencies. This is the responsibility of the Requirements Committee of the Defense Production Administration.

4. Government receives information from industry on specific requirements for materials. Authorized production schedules and allotments of controlled materials are then issued to manufacturers and building contractors. Such authorized production and allotments are kept in line with the over-all programs. This is the responsibility of the claimant agencies and the NPA Industry Divisions.

5. Government provides the additional authority (DO ratings) needed to obtain parts, components, and materials, other than controlled materials, to assure programmed requirements. This, too, is the responsibility of the claimant agencies and NPA Industry Divisions.

5

INDUSTRY'S ROLE IN CMP

Manufacturers and contractors using controlled materials have two basic parts to play in cooperation with Government to make CMP operate smoothly:

1. Industry has the major responsibility for translating essential production needs into materials requirements—both controlled materials and others—and for making this information available to the appropriate Government agency.

2. Industry, obviously, shoulders the responsibility for turning out essential production and construction, as planned and on schedule.

The points of contact between industry and Government are the claimant agencies and the industry divisions of NPA. Prime consumers of controlled materials, that is, contractors on "A" products, and producers of "B" products that are under CMP, furnish requirements information to these Government agencies and obtain authorized production schedules and materials allotments from them. ("A" and "B" products are defined below.)

In the case of "A" products, prime consumers gather the requirements information from their suppliers and in turn pass along materials allotments to their suppliers. CMP procedures take the fullest advantage of the existing lines of communication and authority in normal business practice. The everyday chain of customer-supplier relationships is used as far as possible.

After the first quarter of CMP operations, contacts between business and government will be decentralized as far as possible. In World War II, it was found that the majority of applications for CMP allotment could be handled by the field offices, cutting down paper work in Washington and saving businessmen time, trouble, and expense. In the second quarter of

CMP operation, the majority of applications will go directly from the manufacturer to the nearest Field office of NPA for processing.

6

CMP PRODUCT CLASSIFICATION

In order to make CMP procedures as simple and efficient as possible, all products using CMP materials are *classified* into "A" products and "B" products. But while all such products are classified, not all of them will be included in the CMP programs (for more details on what comes actively under CMP see sec. 7).

For classification purposes, "A" products are those products of special design or for special use which are sold to one or relatively few customers. As a result, it is convenient to gather requirements data and allot materials for "A" products vertically, that is, directly from *customer* to *consumer,* or manufacturer. Information is passed up the line from supplier to direct customer, while authorized schedules and allotments are passed down. Most military products, being of special design, are "A" products—the tank and its specially designed subassemblies are examples. Auto frames, made for one company, are an example of a nonmilitary product, classified as an "A" product.

"B" products, on the other hand, are those of general design, sold to many customers or through many outlets, where it is not convenient or efficient to pass on materials allotments from each customer to the "B" product producer. Manufacturers of "B" products included in the CMP program present requirements data to, and receive schedules and allotments directly from, the appropriate NPA Industry Division.

For classification purposes, the "B" list includes a wide range of common components and parts, such as nuts and bolts, ball bearings, fractional horsepower motors; and it includes the standard civilian products using CMP materials such as automobiles, appliances, farm and office equipment, etc.

7

SCOPE OF THE CMP PROGRAM

As indicated in the preceding section, although all products using the Controlled Materials are *classified* as "A" or "B" products, only certain products will be *programmed* under CMP and receive guaranteed allotments of materials.

Furthermore, a distinction must be made between the list of producers initially requested to file applications and the eventual list of producers who will operate under CMP and receive allotments of specific amounts of materials.

During the first phase of CMP, producers of the following products are required to file applications covering anticipated needs for CMP materials:

1. Manufacturers of military products, products for the Atomic Energy Commission, and certain related defense construction projects.

2. Manufacturers of a selected group of "B" products using steel, copper or aluminum including: Agricultural machinery; construction and mining machinery; oil field machinery; machine tools, metal working machinery and accessories, including welding and cutting apparatus; steam engines, steam and hydraulic turbines; pumps and compressors; conveyors and conveying equipment; elevators and escalators; fans and blowers, industrial; industrial trucks and tractors; mechanical power transmission equipment; heat exchangers, condensers, packaging machines, centrifugals and separators; hydraulic jacks and lubricating devices; motors and generators; switch gear and electrical control apparatus; electrical welding apparatus, including electrodes and welding rods; ships and vessels; locomotives; railroad and street cars; tractors; tin cans; fabricated structural steel products; tanks, boilers and cylinders; stamped and pressed metal products; valves and fittings; antifriction bearings; food products machinery; textile machinery; woodworking machinery; paper making machinery; printing and publishing machinery; special industrial machinery; aircraft and aircraft parts; truck trailers; metal shipping containers; screw machine products; industrial furnaces and ovens; mechanical stokers; office machines; scales and balances; commercial laundry and dry cleaning machinery; measuring and dispensing pumps and lubrication

equipment; commercial service equipment except household types; electrical wiring devices and supplies; electrical indicating and measuring instruments; lighting fixtures; steel springs; bolts, nuts, rivets and other industrial fasteners; collapsible tubes; internal combustion engines; transformers; capacitors, rectifiers, induction and dielectric heating units; electrical accessory equipment for internal combustion engines; electric lamps, incandescent and fluorescent; radio, radar and television equipment, except home type; radio tubes; telephone and telegraph communication equipment; storage batteries; primary batteries, dry and wet; X-ray and therapeutic apparatus; motor vehicles except passenger type; small arms; small arms ammunition; cooperage; partitions, lockers and shelving; window and door screens; restaurant furniture; paperboard boxes; fiber cans, tubes and drums; periodicals; books; cutlery; edge tools; hand tools; files and rasps; hand saws and blades; other hardware; plumbing fixtures; oil burners; heating and cooking equipment except residential; metal doors and sash, frame, etc.; sheet metal products such as roofing, culverts, etc., except awnings and radiator enclosures; scientific and surveying instruments; mechanical measuring and controlling instruments; optical instruments and goods; dental, surgical and medical instruments and appliances; photographic equipment; clocks and watches, etc.

3. Manufacturers of repair and replacement parts.

During this same period, the producers of the following products are not required to file applications:

Motor vehicles—passenger type; household refrigerators and freezers and comfort air conditioning; heating and cooking equipment—residential; household electrical appliances; vending and amusement machines; sewing machines—household; vacuum cleaners—household; home radio and television sets; automobile trailers (not incl. truck or house trailers); sheet metal awnings and radiator enclosures; venetian blinds; household furniture; professional furniture for beauty and barber shops; window shades; women's hand bags; small leather goods; household stamped and pressed metal products (including enameled); domestic laundry machinery; household service equipment, such as dishwashing machines, water softeners, polishing machines; motorcycles and bicycles; jewelry and jewelry findings, silver and plated ware; pianos, organs, musical instruments and parts; games and toys, children's vehicles; dolls; sporting and athletic goods; artist materials; costume jewelry; artificial flowers; lamp shades; barber and beauty shop equipment; signs and advertising displays; umbrellas and canes; cigarette holders and tobacco pipes; soda fountain and beer dispensing equipment.

It is important to note that not all producers who are asked to file applications, will necessarily receive allotments of CMP materials, and that other producers, not now required to file, may eventually come under the active CMP program.

When complete requirements information has been gathered, studied, and related to the total supply of CMP materials, the Government will have the detailed information necessary to determine the exact scope of CMP programs and authorize production schedules for the period ahead. This is, of course, a continuing process—requirements and program policy will be reviewed and adjusted as conditions change.

Since the purpose of CMP is to assure completion of essential production and construction with a minimum of interference with the civilian economy, the following can be taken as a rule-of-thumb guide to those products which are likely to be a part of the active CMP program:

1. The great majority of "A" products, which will include military and other direct and defense supporting items.

2. A selected list of "B" products (official NPA "B" list) particularly the common components and parts essential to a wide variety of defense and other essential production, like ball bearings and fractional horse-power motors. Industrial machinery and equipment are also likely to be included in the programming.

3. Construction of plants and facilities directly related to defense and essential civilian needs.

It is important to recognize that the Controlled Materials Plan is an open-end plan, as adapted for the current period. Producers under CMP are not limited entirely by the authorized production schedule and materials allotment that they receive under the plan. They are free to seek materials in the free market and to produce beyond authorized production schedules to the extent that other NPA regulations permit.

8

CMP IN OPERATION

As an example of CMP in operation, here are the major steps that would be taken in a military tank program:

1. The Department of Defense needs a large quantity of a

certain type tank, and negotiates a contract for its production with Company X.

2. Company X, the prime contractor (or "prime consumer" under CMP definition) determines a production schedule and requirements for controlled materials. Company X then gets the controlled materials requirements from its suppliers of "A" products. ("B" product suppliers do not figure in this CMP compilation.)

3. Company X totals up the combined requirements for the contract—both as to quantities and delivery schedules—and presents the whole picture to the procuring claimant agency.

4. The Department of Defense (the claimant agency in this case)—adds the requirements for this tank contract to its other programs and presents a total claim for controlled materials to the Program Bureau.

5. The Program Bureau of DPA examines this claim, along with those of the other claimant agencies, weighs the combined total against the supply of controlled materials for the period ahead, and then authorizes a program and allots controlled materials to each Claimant. (If combined claims exceed supply or cut too deeply into the civilian reservoir of CMP metals, claims may be cut back.)

6. The Department of Defense, now having a total allotment of controlled materials, breaks this allotment down among its many programs according to its determination of relative importance.

7. For the tank contract in question, the Department of Defense then gives Company X an authorized production schedule, an allotment of controlled materials and an allotment number, and also issues a DO rating for the procurement of "B" components and other materials (rubber, tin, etc.).

8. Then Company X (the prime consumer) passes along the allotment and the DO rating to its suppliers of "A" components so they can obtain needed controlled materials and "B" products to meet production schedules. If Company X also happens to manufacture a "B" component of the tank in its own plant, it makes separate application for an allotment of controlled materials to the appropriate NPA Industry Division.

While these operating steps under CMP place an extra burden above the normal flow of customer-supplier negotiations, the resulting advantages clearly outweigh the inconvenience. Government can be sure that total production planned for any period is in line with the supply of materials, and can guarantee that the materials will be available. And industry can be sure that all components of a complicated product will be produced and delivered in the quantities and at the time they are needed to turn out a finished product.

9

PRINCIPAL REGULATIONS

In view of the fact that many persons in Government and in industry were familiar with CMP in World War II, the current regulations are patterned after the previous plan as to terminology, procedures, and forms.

While this booklet is not intended to include the complete regulations or the technical operating details, the scope of CMP regulatory provisions and the principal definitions are helpful in understanding the plan.

The basic provisions and requirements of the Controlled Materials Plan will be covered in seven regulations. Their scope and purpose is outlined as follows:

CMP REGULATION 1

The purpose of this regulation is to define rights and obligations under the Controlled Materials Plan. It explains how production schedules are authorized for manufacturing operations and how materials are obtained to complete such production schedules.

CMP REGULATION 2

Inventories

This regulation forbids the accumulation of excessive inventories of controlled materials. It does this by limiting the quantities of such materials that can be ordered, received or delivered.

CMP REGULATION 3

Preference status of delivery orders

The purpose of this regulation is to define, under the Controlled Materials Plan, the preference status of delivery orders for controlled materials and delivery orders for products and materials other than controlled materials.

CMP REGULATION 4

Deliveries of controlled materials by distributors

This regulation describes how distributors make deliveries of controlled materials under the Controlled Materials Plan.

CMP REGULATION 5

Maintenance, repair and operating supplies

This regulation explains how controlled materials and products and materials other than controlled materials are obtained for MRO and minor capital additions.

CMP REGULATION 6

Construction

The purpose of this regulation is to explain how to get materials for construction under the Controlled Materials Plan.

CMP REGULATION 7

CMP materials for repairman

In this regulation, the rules under which a repairman may buy controlled materials, and products and materials other than controlled materials, are explained.

10

CMP DEFINITIONS

The important definitions used in the CMP regulations and forms include:

"NPA" means the National Production Authority.

"Controlled Materials" mean carbon steel (including wrought iron), alloy steel (except stainless steel), stainless steel, copper, copper base alloys, and aluminum, in each case in the forms and shapes indicated in Section 12.

"Controlled Materials Division" means the Iron and Steel Division, the Copper Division or the Aluminum and Magnesium Division of NPA.

"Industry Division" means the division or other unit of NPA which is charged with supervision over the operations of the producers of particular products. (See list—sec. 11.)

"Claimant agency" means any government agency authorized to present controlled materials claims for an individual segment of industry.

"Prime consumer" means any person who receives an allotment of controlled material from a claimant agency or an Industry Division.

"Secondary consumer" means any person who receives an allotment of controlled material from a person other than a claimant agency or an Industry Division (i. e., from his customer in industry).

"Allotment" means (1) an authorization by the requirements committee of the Defense Production Administration of the amount of controlled materials which a claimant agency or an Industry Division may allot during a specified period; or (2) an authorization by a claimant agency or an Industry Division of the amount of controlled materials which may be received and allotted by one of its prime consumers; or (3) an authorization by a prime or secondary consumer of the amount of controlled materials which may be received and allotted by one of its secondary consumers.

"Program" means a statement of the amounts of an item or class of items to be provided in specified periods of time.

"Authorized program" means a program specifically approved by the requirements committee of the Defense Production Administration.

"Production schedule" means a statement of the amounts of an item or class of items to be produced by an individual consumer in specified periods of time.

"Authorized production schedule" means a production schedule specifically approved by a claimant agency or by an Industry Division with respect to a prime consumer, or specifically approved by a prime or secondary consumer with respect to a secondary consumer.

"Delivery order" means any purchase order, contract, shipping or other instruction calling for delivery of any material or product on a particular date or dates or within specified periods of time, and which does not contemplate that further instructions are to be given.

"Authorized controlled material order" means any delivery order for any controlled material which is placed pursuant to an allotment as provided in section 21 of this regulation or which is specifically designated to be such an order by any regulation or order of NPA.

11

NPA INDUSTRY DIVISIONS

The Industry Divisions of NPA are the principal points of contact for producers of "B" products who are affected by CMP directly or indirectly. They will handle allotments of controlled materials to these producers, and are the proper recipients for appeals and claims.

Aircraft.
Agricultural Machinery and Implements.
Aluminum and Magnesium.
Building Materials.
Chemicals.
Communications Equipment.
Construction and Mining Machinery.
Consumers Durable Goods.
Containers and Packaging.
Copper.
Electrical Equipment.
Electronics.
Engine and Turbine.
General Components.
General Industrial Equipment.
Iron and Steel.
Leather and Leather Products.
Lumber and Lumber Products.
Miscellaneous Metals and Minerals.
Motion Picture-Photographic Products.
Motor Vehicles.
Ordnance, and Shipbuilding.
Printing and Publishing.
Pulp, Paper and Paperboard.
Railroad Equipment.
Rubber.
Scientific and Technical Equipment.
Service Equipment.
Textile.
Tin, Lead and Zinc.

12

CMP MATERIALS

The application forms CMP-4A and CMP-4B used to make application for allotments of controlled materials are similar to those of World War II. Producers will be asked to state value of shipments and unfilled orders; to indicate production schedules in units or other appropriate measure; to list total requirements for controlled materials; and, where the quantities are substantial, to break these requirements down into details as to sizes and shapes.

Form CMP–4A is for the use of producers of "A" products, CMP–4B is used by those making products on the "B" list who are asked to file. Construction requirements are filed by contractors on a similar form CMP–4C.

The controlled materials are defined as follows:

- CARBON STEEL (including wrought iron):
  - Bar, rod, shapes, rails.
  - Sheet, strip, plate, tin mill products.
  - Pipe, tubing.
  - Wire, wire products.
  - Castings.
  - All other steel mill products (except forgings).
- ALLOY STEEL:
  - Bar, rod, shapes.
  - Sheet, strip.
  - Plate.
  - Pipe, tubing.
  - Wire,
  - Castings.
  - All other steel mill products (except forgings).
- STAINLESS STEEL:
  - Seamless tubing.
  - Castings.
  - All other steel mill products (except forgings).
- ALUMINUM:
  - Bar, rod, wire.
  - Sheet, strip, plate, foil, rolled shapes.
  - Extruded shapes, tubing.
  - Castings.
  - Forgings, pressings, impact extrusions.
  - Powder (atomized, flaked, paste).
  - Pig, ingot, pellet, granules, shot.
- COPPER (unalloyed):
  - Sheet, strip, plate, rolls.
  - Bar, rod, shapes, wire (except electrical).
  - Pipe, tubing.
  - Wire and cable for electrical conduction only (report copper content only).
  - Castings, molded shapes.
- COPPER-BASE ALLOY:
  - Sheet, strip, plate, rolls.
  - Bar, rod, wire, shapes.
  - Pipe, tubing.
  - Castings, molded shapes.

EXCERPT : Chapter 5, "Accelerating Production"

UNITED STATES BUREAU OF THE BUDGET

COMMITTEE ON RECORDS OF WAR ADMINISTRATION
WAR RECORDS SECTION

The United States at War

DEVELOPMENT AND ADMINISTRATION OF THE WAR PROGRAM BY THE FEDERAL GOVERNMENT

DA CAPO PRESS • NEW YORK • 1972

CHAPTER

5

Accelerating Production

THE ATTACK at Pearl Harbor and the war declarations which followed put an end to the inhibiting doubts which beset our national policy and action during the preceding year. Though few grasped the meaning of "total war" even after war was declared, all were ready to exert every effort and to make sacrifices for eventual victory. There was a single national purpose as clear and dominant as can be found in the history of any people.

On all sides it was recognized that war production was an extremely important factor in building the military power both of ourselves and of our allies. Even so, the President's clarion call for 60,000 planes, 45,000 tanks, 20,000 antiaircraft guns and 8,000,000 tons of shipping in the single year 1942 almost took the breath away from many war chieftains, industrial leaders, and production economists. "He set the sights so high indeed," said Hanson Baldwin, the military expert of the New York *Times*, "that it will be an industrial miracle if we achieve these goals." Baldwin thought that we might double, but would hardly treble, our plane production in a single year.

In spite of the doubts and timorous counsels of practical and expert men, the President set our goals high, and the Nation drove forward as a unit for "all-out" war production.

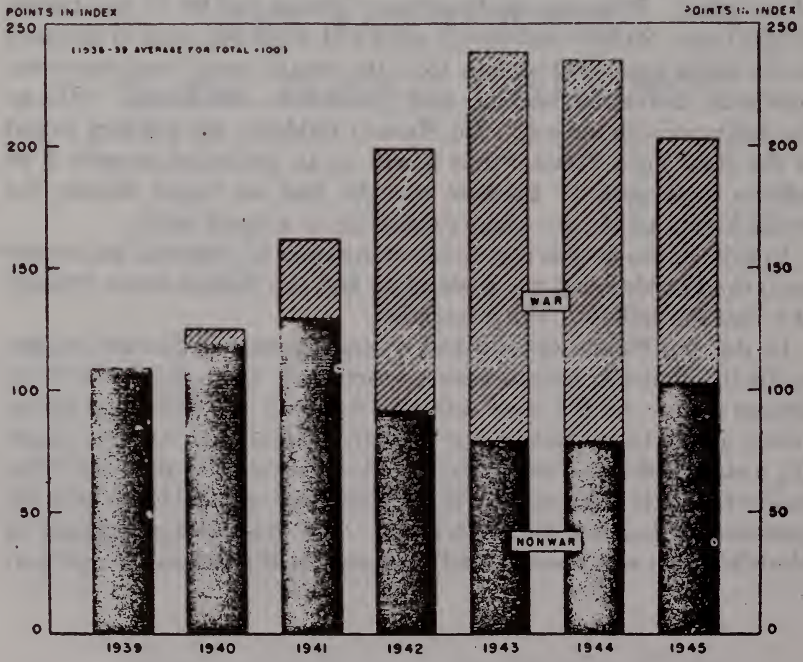
In this the Nation already had a running start in the production, contracts, controls, administrative machinery, and experience of the defense days. At the time war was declared we were already devoting about 15 percent of our industrial production to war, (chart 11), a start of the greatest significance both in speeding the production build-up and in determining the administrative machinery and the personnel of our war administration. The gradual development of administrative organization and processes in the defense period permitted a smooth change-over to war conditions. Sharper definitions of responsibility, broadening of authority, and renaming of existing agencies and officials could be accomplished without interrupting the acceleration of their activities.

Immediate Administrative Adjustments

The new drive for production under war conditions called for the immediate abandonment of the slow processes of debate, consultation, board action, and the inconclusive influence of advisory interdepartmental agencies, and for the substitution of administrators with authority to act with dispatch, and power to command both public agencies and private enterprises to do their parts in the national effort.

Within a few months after the outbreak of war, a series of changes in the war-production machinery of the Government of the United States was made. In some instances these changes were made by the President under the power he possessed to organize and reorganize the agencies within the Office for Emergency Management. In other

CHART 11. *Industrial Production.*



Source: Board of Governors of the Federal Reserve System.

instances, he acted under authority granted by the First War Powers Act[1] which enabled him to reassign the functions of departments and agencies established by statute. The extension of this power by Congress permitted the accomplishment of some administrative changes which were overdue but had not been feasible earlier because of lack of power in the Executive to act.

The War Production Board was created with all the President's powers over industry, production, raw materials, factories, machine tools, priorities, allocations, and rationing. The Office of Production Management and the Supply Priorities and Allocations Board were abolished, and their duties and personnel were transferred to WPB. The Army-Navy Munitions Board was ordered to report to the President "through the Chairman of the WPB."[2]

All the powers of WPB were placed in the hands of one man, Donald M. Nelson. The "Board" itself was purely advisory, and served to bring around the council table for weekly meetings the top production representatives of the War, Navy, and Commerce Departments, the Board of Economic Warfare, and the Price Administrator as well as a representative of the White House.

The Office of Price Administration was placed on a statutory basis with power to stabilize prices, eliminate hoarding, and prevent speculation.[3] All the powers of the OPA were assigned to the Administrator, Leon Henderson. OPA was also given the administration of rationing by Donald Nelson, through WPB Directive No. 1 of January 24, 1942.

The War Manpower Commission came into being on April 18, 1942, with broad coordinating and "directive" powers over manpower, labor assignment to industry, employment and training, and all agencies of the Government dealing with the use of manpower in the war effort were placed under the Commission.[4] Such powers as the Commission had—and these did not include the right to draft, assign, or punish civilian workers—were entrusted to the Chairman of the WMC, Paul V. McNutt, "after consultation with" an interdepartmental commission representing War, Navy, Agriculture, Labor, War Production Board, National Housing Agency, Office of Defense Transportation, War Shipping Administration, the Civil Service Commission, and the Federal Security Agency. Other advisory committees were set up including a Management-Labor Policy Committee, a Women's Advisory Committee. The Committee on Fair Employment Practice, which had been established in June 1941 to eliminate racial discrimination in employment, was a part of the WPB until July 30, 1942, when it was brought into WMC.[5]

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[1] Adopted by Congress, Dec. 18, 1941.

[2] Executive Order No. 9024, Jan. 16, 1942, 7 *Federal Register* 329; Executive Order No. 9040, Jan. 24, 1942, 7 *Federal Register* 527; Executive Order No. 9125, Apr. 7, 1942, 7 *Federal Register* 2719.

[3] 56 *Stat.* 29.

[4] Executive Order No. 9139, Apr. 18, 1942, 7 *Federal Register* 2919.

The National War Labor Board was established on the foundations of the National Defense Mediation Board, on January 12, 1942.[6] The Board was made up of 12 members, 4 representing the public, 4 the employee, and 4 the employer and was given final jurisdiction over all labor disputes and over wage and salary rates except as to the railroads.

The Office of Defense Transportation, the creation of which had been under consideration prior to Pearl Harbor, was set up under Joseph B. Eastman as Director to exercise the President's powers over the coordination and direction of all "domestic transportation systems."[7] These powers were subsequently extended to cover "all rubber-borne" civilian transportation, including the use of private cars.[8]

The War Shipping Administration was created on February 7, 1942, to operate and maintain shipping owned by the United States and to allocate all vessels under the United States flag or subject to United States control, to provide insurance, and to administer priorities in shipping in accordance with such schedules as might be transmitted by the WPB.[9] The Administrator was Admiral Emory S. Land. Lewis W. Douglas, as his deputy, handled ship utilization and priorities.

The National Housing Agency was created to bring under one Administrator, John B. Blandford, Jr., all the housing planning, construction, management, and financing agencies of the Government and to supersede the Division of Defense Housing Coordination which had been established within the OEM.[10]

The Civil Service Commission on March 15, 1942, issued regulations to facilitate the recruitment of additional personnel needed to man the war agencies. All new appointments became "war service" appointments and could be made under rules and administrative arrangements permitting expeditious action. The action by the Commission was the culmination of a series of measures beginning in mid 1940 and was taken under broad authority delegated by the President.[11]

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[5] Presidential Letter of July 30, 1942. (FEPC established by Executive Order No. 8802, June 25, 1942, 6 *Federal Register* 125.)

[6] Executive Order No. 9017, Jan. 12, 1942, 7 *Federal Register* 237.

[7] Executive Order No. 8989, Dec. 18, 1941, 6 *Federal Register* 6725.

[8] Executive Order No. 9156, May 2, 1942, 7 *Federal Register* 3349.

[9] Executive Order No. 9054, Feb. 7, 1942, 7 *Federal Register* 837.

[10] Executive Order No. 9070, Feb. 24, 1942, 7 *Federal Register* 1529; Executive Order No. 8632, Jan. 11, 1941, 6 *Federal Register* 295.

[11] Executive Order No. 9063, Feb. 16, 1942, 7 *Federal Register* 1075.

Reorganization of the Procurement Services

The creation of the WPB did not, as a matter of fact, shift the procurement activities from Army Ordnance, the Bureau of Ships, the Quartermaster, Treasury Department, the Bureau of Supplies and Accounts, the Navy Bureau of Ordnance, the Army Air Corps, the Maritime Commission, or the other independent procurement authorities which were concerned with placing contracts for war materials, construction, and supplies. The power to take over all these activities was assigned to the WPB by its Executive order, but Mr. Nelson had no intention of assuming the procurement and contracting functions. As he said to the Truman Committee:

> I have gone even to the point of being overzealous in seeing that the contracting power is kept within the Army and Navy.
>
> We had one of two courses to take when we took this job. Many urged that we set up a buying organization independent of the Army and Navy. I knew, sir, that that would be just dead wrong and didn't even consider it for 5 minutes, because it would have been impossible to have gotten the type of men that we wanted to come here and do that job with the contracting power without having subjected themselves to great criticism. So, in setting it up, we were very careful not to take a bit of authority away from the Army or the Navy. As a matter of fact, we enhanced that authority.[12]

It was also Mr. Nelson's view that the effort to take over procurement in 1942 would only have slowed up production which had already reached a monthly total of $2.2 billion by January.[13]

* * * * * * *

Transition to War Production Board

In taking over SPAB, OPM, and the new powers which went to make up the WPB, it was Mr. Nelson's policy to rule gently and use as much of the prior personnel and machinery as possible. He feared the loss of momentum, and the delays incident to new organization and new men.

In place of the Director General and Associate Director General of OPM, there was now a single head with all power. In place of the debating and resolving SPAB, all of the authority and responsibility went to Nelson, though most of the same people still sat as his advisors in the WPB.

Personnel changes in WPB were minor except at the top. Mr. William S. Knudsen, though greatly handicapped by the mounting problems of his weak and bifurcated organization, had made a great contribution especially toward the expansion of facilities. He went to the War Department with the rank of Lieutenant General to be the top advisor or production.

All of the OPM and SPAB activities were continued in WPB though the effort to tie labor into the operation was curtailed with the disappearance of Mr. Hillman as a codirector. He continued nominally to head the Labor Division, but actually dropped out of the picture. Mr. Hillman's health was bad, and he soon indicated his desire to resign. He remained, however, until further functions were transferred out of WPB in the creation of the WMC. At that time the President recognized that the assignment was no longer in keeping with his stature and in a telegram to Hillman at a hospital in Washington asked him to become instead a "Special Assistant" to the President "in labor matters."

Another shift was the abandonment of Floyd Odlum's vigorous campaign for "contract distribution." Odlum disappeared, his elaborate organization was absorbed, for the time being, in other divisions of WPB and the papers and radio were no longer filled with his exhortations for the enlistment of the small manufacturer in munitions production.

In the shift from OPM to WPB the most important developments were, however, not the activities which were deemphasized or dropped, but the new activities which were given an organizational basis. These were the Requirements Committee, the Planning Committee, and the pulling together in a single organization of Industry Operations and of Priorities. The Field Service was established, as was a Bureau of Government Requirements. Otherwise, the organization units devoted to production, purchases, civilian supply, materials, and statistics went on much as before.

Under these new arrangements, the Planning Committee, under Robert Nathan, freed from all administrative responsibility, was designed to analyze what was happening, study the impact of the production program on the American economy, and make suggestions to the chairman on major policy matters. The Requirements Committee, on the other hand, was given a more restricted and immediately practical role. It was given the task of adding up the raw material requirements of all the claimants, getting the requests cut back so that they would not exceed the supplies, and then dividing up the supplies, commodity by commodity, among the claimants so as to produce the most satisfactory total result. Each 3-month period was treated as a separate unit, and the effort made to allocate to each claimant agency enough steel to go with its copper, enough nickel to go with its rubber. The Requirements Committee reflected another step in the institutionalization of arrangements for the allocation of our total resources among competing uses. This general objective had been one of the dominant purposes in the creation of the Supply Priorities and Allocations Board. With the rapid growth of munitions production and the increasing pressure upon our resources, it was imperative that better means be found to make allocations of resources. The Requirements Committee, like SPAB, was plagued by the inadequacy of data on which to base decisions and by the inadequacy of arrangements to assure that its broad decisions were executed in detail.

While the Planning Committee was a small cohesive group of men of broad comprehension of policy problems, the Requirements Committee was made up of representatives of the leading claimants, each fighting to keep the other fellow's piece of the material pie small and his own big. Though the decision always rested with Mr. Nelson's representative in this struggle, the lion's share went to meet immediate military demands, to the undue sacrifice at times of equally good claims of the railroads, of housing for workers, mining machinery and agricultural tools, or of aid to the Allies.

In the new WPB set-up, the materials branches, like those concerned with steel, copper, and aluminum, were part of the same broad organization as the Requirements Committee. They were thus responsible for passing out the critical raw materials to the users in general accordance with the determinations of the Chairman of the Requirements Committee as certified to them.

The materials branches were primarily responsible also for inducing or forcing conservation in the use of their particular material, although there were also especial sections of WPB concerned with conservation and revision of specifications. While the WPB thus had some influence on the simplification of specifications to make production easier, the most effective work of this sort was done by civilian manufacturing experts who were made a part of the military procurement offices under the "infiltration" policy mentioned below.

The demands for steel, copper, aluminum, and other materials came to the producers and raw material handlers through an entirely different channel. This demand started with the placing of contracts by the extremely active and independent procurement agencies—the Army Services Forces, the various Navy bureaus, the Maritime Commission, and Treasury Procurement. These contracts carried with them priorities; that is, rights to have components and materials ahead of anyone else who did not have an equal or higher priority rating. The final authority to control the issuance of priorities was in WPB. In order not to disturb a going system and cause delay, Mr. Nelson continued the priority system which had been built up under the Office of Production Management, and immediately authorized the Army-Navy Munitions Board to assign priorities to all Army, Navy, Maritime, and Coast Guard procurement. These priorities were "extensible"; that is, any contractor who had an "A" priority order could place that priority on any material which he in his own judgment decided that he needed to do the work. All other priorities, including a great many secondary priorities for military end products, were assigned through the Priorities Division and the industry divisions of WPB, all of which were now placed under the supervision of Mr. J. S. Knowlson. The priority power was thus officially delegated to him.

In the early days of WPB, manufacturers who needed priority assistance to get hold of steel, aluminum, valves, motors, wire, lumber, cement, wheelbarrows, refrigerators, paint brushes, or other items required for production would fill out an application explaining for what they needed the material or article, and on the basis of the rating on an approved list of the thing they were making, they would receive a high priority, a low priority, or no priority. Originally these applications, except for those handled by ANMB, all came in to Washington, as many as 130,000 a week during June 1942, and they were "processed" through the industry branches and the priority division, rated, and sent back to the plants and factories of America. Later on, a considerable part of this work was decentralized to the field.

The Impact of Unlimited Procurement

Under the traditional American system, industry does not produce war munitions until there are Government orders; Government orders are not placed until there are appropriations; and appropriations are not made until requests based on estimates and supporting information are submitted to Congress for action. In fact, in peacetime, the control over the whole process centers in the appropriation by Congress. It was natural, therefore, for procurement officers not to take vigorous action to raise war production before appropriations were available. Not only was this against the whole tradition of the past, but it would, if carried far enough, have been a criminal offense. But any restriction, real or imagined, imposed by appropriations, disappeared after the declaration of war. Appropriations were made in lump sums, so that appropriation language no longer limited the military agencies in their war activities.

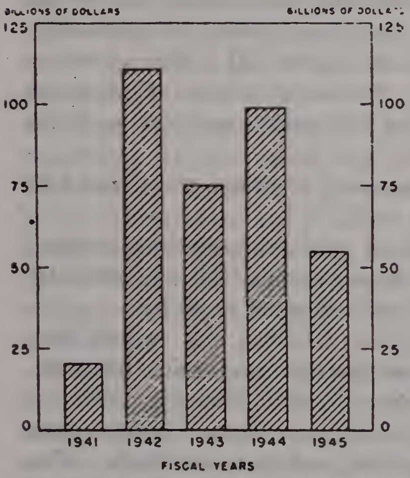

CHART 12. *Federal Appropriations for War.*

Source: Treasury Department.

While Congress had slowed up the building of training camps only a few months earlier, it now acted with great dispatch. Within 6 months, almost $100,000,000,000 was appropriated, and in the next 4 months another $60,000,000,000 was added (chart 12). Of these stupendous authorizations, the Army received $95 billion, the Navy $50 billion, lend-lease $5 billion, and the Maritime Commission $3.5 billion. Never before or since, have such immense financial authorizations been given in so short a period.

By spring the floodgates were open. Equipped with virtually unlimited financial authorizations, the procurement agencies went to work to place their contracts with the industries of America. This was not too difficult. Industry was now eager to get into war work, especially as the WPB materials orders and limitation orders began to interfere with normal production of civilian items. The services were equipped with high priorities, which gave the contractors confidence that they would be able to get the materials and components they required, price arrangements were generous and elastic, and the manufacturers were not unwilling, under pressure, to sign additional contracts even when their plants were already full, hoping to expand, or find some other method of discharging their inflated obligations. With this combination of circumstances, over $100 billion of contracts were placed in the first 6 months of 1942.[16] In other words, industry signed up to deliver for war more than the total production of the American economy in the Nation's most prosperous and productive prior year. At the time there were also some $20 billion of orders outstanding, mostly for munitions. The new orders included $68 billion for munitions, $12.6 billions for industrial expansion, and $6.9 billions for military construction.[17]

Under this flood of war orders, a number of things were bound to happen, and did happen.

First, it became utterly impossible to produce everything ordered at any time in any near future. It was an industrial impossibility. The total called for was in excess of our industrial capacity.

Second, there was a resulting collision between the various production programs and between the men who were responsible for them. Merchant ships took steel from the Navy, and the landing craft cut into both. The Navy took aluminum from aircraft. Rubber took valves from escort vessels, from petroleum, and from the Navy. The pipe lines took steel from ships, new tools, and the railroads. And at every turn there were foreign demands to be met as well as requirements for new plants.

Third, all semblance of balance in the production program disappeared because of the different rates of contracting and of production that resulted from the scramble to place orders. If there ever had been a planned balance between men, ships, tanks, planes, supplies, weapons, ammunition, and new facilities, and there is no evidence that there was, that balance disappeared in the differential time required to develop the orders, the differential energies of the various procurement officers, and the differential difficulties of getting production out.

Fourth, there was terrific waste in conversion. After a tragically slow start, many a plant was changed over to war production when its normal product was more needed than its new product. Locomotive plants went into tank production, when locomotives were more necessary—but the Tank Division did not know this. Truck plants began to produce airplanes, a change that caused shortages of trucks later on. In some cases, plants were converted at great cost of steel and copper, when a fraction of the precious metals involved would have brought a greater return at some other place in the economy. The scramble for a production we could not attain, brought us waste instead.

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[16] WPB, *Report on Production*, 1942, p. 27.

[17] *Ibid.*, p. 27.

Fifth, we built many new factories, and expanded many others, which we could not use and did not need. Many of these factories we could not supply with labor or with raw materials, or if we had, we would not have been able to fly the planes or shoot the ammunition that would have come out of them. But in the process we used up critical materials and manpower which might better have gone into something else. In the light of the tremendous contracts outstanding especially in the early part of 1942, however, these plants seemed necessary to some people, and under the system they were given high priorities. In most cases they were also financed by the Government. The result was, however, an overconcentration of contracts in the larger corporations and a failure to fully utilize the facilities of many small manufacturers whose plants could have produced "bits and pieces."[18] It did not escape the attention of Congress that better utilization of small plants could have reduced the necessary expansion of facilities.

Finally, the priority system broke down because of "priority inflation." People with military contracts had the right to take more scarce materials and components than there were, so that a priority or an allocation became nothing more than a "hunting license." In other words, those who were issuing priorities did not limit their high-ranking authorizations within the allocations given them by the Requirements Committee. In fact, there was very little connection between the two, partly because the allocations were based on a quarterly time schedule, while the priorities carried no terminal date and were good at any time.

Whether it would have been possible, within the time available, by better planning of procurement to prevent the consequence of indiscriminate placement of contracts without delaying the advance of production is a complex question. The determination of the construction program for ordnance plants, for example, required not only that we know in what quantities and at what times a particular ordnance item would be needed, but also that the output rate of plants producing by new methods and on unprecedented scales be predicted. Control over other types of procurement would have required types of data, such as the usage of materials in the manufacture of particular items, and administrative techniques not yet developed. Whatever the hypothetical possibilities might have been, the general policy in the first few months of the war was to permit the placement of contracts until difficulties developed. Then the War Production Board proceeded to deal with the problems born of experience.

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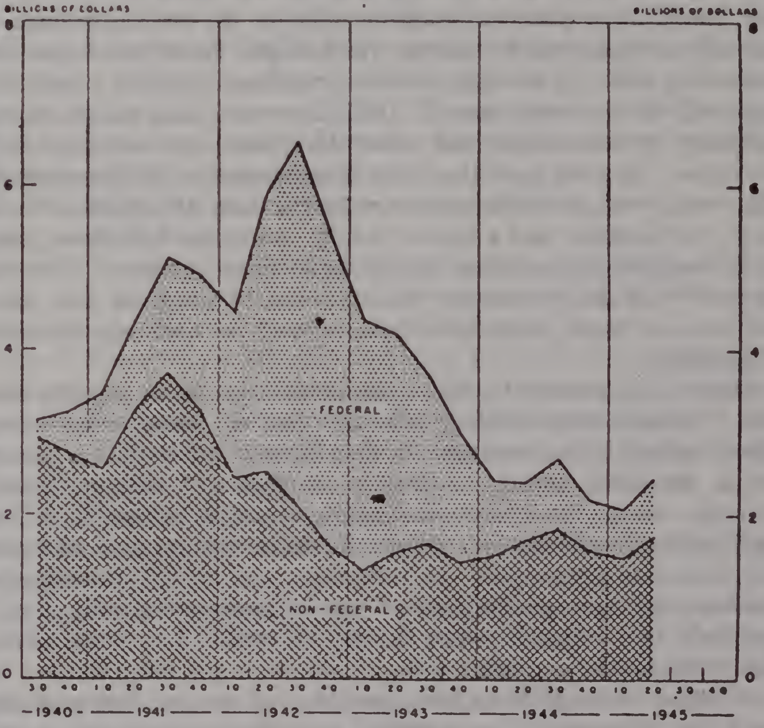
[18] Up to December 1942, 71 percent of all war contracts had been awarded to the 100 largest contractors. See in this connection U. S. Congress, Senate. *Economic Concentration and World War II.* Report of the Smaller War Plants Corporation to the Special Committee to Study Problems of American Small Business. 79th Cong., 2d sess., No. 6.

A Department of Commerce survey in the spring of 1943 indicated substantial unused capacity in the hands of small business firms. *Survey of Current Business*, July 1943, pp. 19–24; Sept. 1943, pp. 19–24.

CHART 13. *Productive Facility Expansion by Source of Funds.*



Source: Civilian Production Administration (formerly War Production Board).

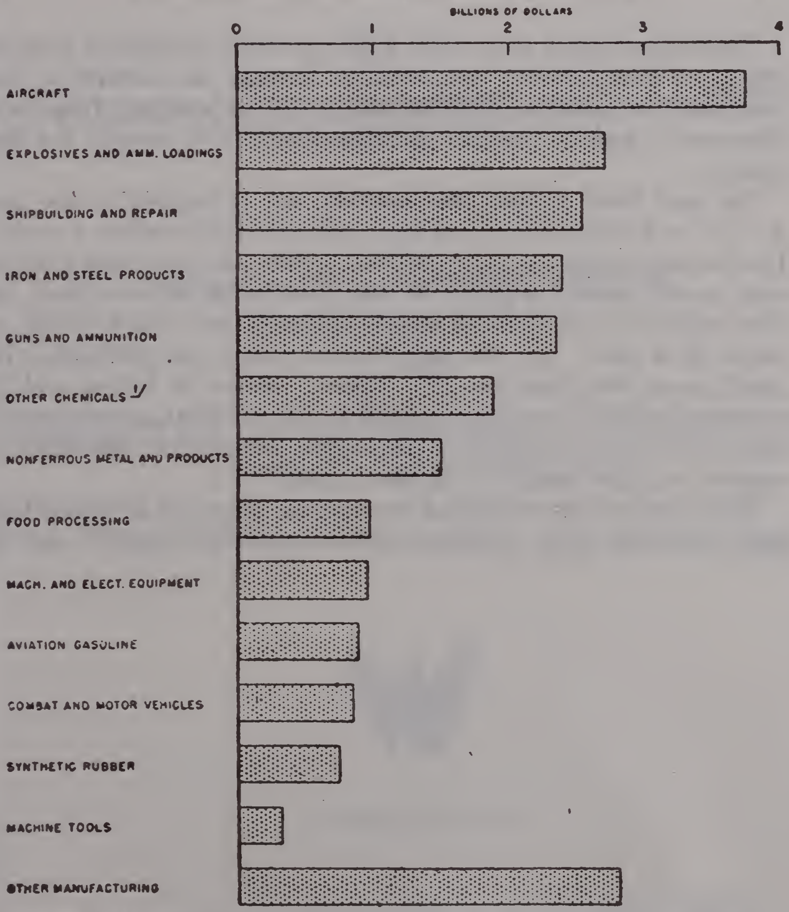
Facilities

The problem of factory construction and expansion received early attention. In the middle of March 1942 the Planning Committee reported that facilities expansion was out of balance and would run ahead of all possible use. In spite of control measures initiated by WPB, the same warning had to be repeated on May 6 and again on June 12. In April Order L–41 prohibited all further facilities expansion without prior WPB approval. Under this order, projects initiated on request of the services received automatic approval. A number of expansions were stopped, however, like the Higgins Shipyards project, and a rather ineffective committee was set up to cut back all facilities which could not come into production by the middle of 1943.[19] The problem was discussed in the War Production Board itself, and it was generally agreed that further expansion of facilities was undesirable with certain exceptions designed to meet specific critical shortages. The chief expansions of this sort were for aviation gasoline and synthetic rubber.

As a result of these efforts, there was a sharp reduction after the

CHART 14. *Manufacturing Facility Expansion by Industry*

[Third Quarter 1940 through Second Quarter 1945.]



[1] Includes coal and petroleum products.

Source: Civilian Production Administration (formerly War Production Board).

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[19] WPB, *Minutes*, June 16, 1942.

middle of 1942 in facilities expansions initiated. Six months later actual construction and then tooling up began to drop off as well. By this time we had finished building the bulk of our aircraft, ammunition, steel, aluminum, magnesium, petroleum, shipbuilding, and other plants, as well as our military camps and establishments and wartime housing, street, water and sewer works.

Eventually the facilities program was brought into reasonable balance more by material shortages, suasion, and debate than by the exercise of controls.

* * * * * * *

The United States production build-up which commenced with the attack on Pearl Harbor and extended through the summer of 1942 was one of the great accomplishments of the war, and one of the major elements in making possible the offensives which brought the final victory.

Up until Pearl Harbor, the monthly rate of increase in war production and construction had been not over $100 million a month. For December this was raised to $440 million, and from that point on each month showed a gain over the prior month of something like $400 million for a period of 9 months, when the rate was markedly reduced for a time. For the period under review, war production per month arose from less than $1.5 billion to almost $5 billion, and the percentage of the economy engaged in war production rose from 15 percent to about 33 percent, a stupendous shift-over of the American economy within a period of less than a year.

This result was accomplished by national unity and determination, high production goals, unlimited authorizations by Congress, and the

94th Congress }
1st Session }
COMMITTEE PRINT

MATERIALS SHORTAGES

WORKSHOP ON RESOURCE MANAGEMENT

PERMANENT SUBCOMMITTEE ON INVESTIGATIONS

OF THE

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UNITED STATES SENATE

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11

SUGGESTIONS FROM THE PAST

The authors of the two conference working papers felt that the CMP worked well in World War II and the Korean War. They suggested that the planning and information gathering functions of the program could and should be used in the management of the nation's energy needs. The workshop generally agreed with their findings on this point. Following is an excerpt from the paper by David Novick in which he summarizes four observations about factors affecting allocation and planning.

Economic Conditions Will Set the Stage

First, I'll venture a prediction: If the National economy is at a 1973 level, it will be difficult to facilitate any significantly expanded new energy program, with or without a materials control system. If it's a 1969–1970 situation or worse, it will be relatively easy to get it rolling—if the management method used doesn't generate its own problems as was done by the 1940 and 1941 priority system.

In this connection, the parallel is clear in one respect! Whatever the level of the economy, there will be competition for limited resources available, and there will be need for decisions that pick and choose among the competing demands.

Discover the Magnitude of Total Demand

At any time at which any of these categories—critical products, critical materials, critical labor or management skills—are in short supply, some kind of resource allocation will need to be considered. How and whether it will have to be invoked depends on the magnitude of the resource demand in the program for which preferred treatment may have to be sought.

Some Central Planning and Policy Authority Is Absolutely Essential

For the 1975–1995 Energy Program, probably the major lesson to be applied is that the triple operation of planning, policy making and implementation must be carried out with constant reference to the importance of each individual part. This is required by the circumstances that the construction and industrial production phases of an energy expansion program must precede the time when the new power plants are actually in use, and well before the construction phase, the introduction of the mobile cranes and earth moving equipment must be available for the building of new facilities.

You Can't Succeed Without Wide Public Support

The final item is people. There will have to be recruitment from business, academe, government and the energy-related industries. The historic experience makes it clear that such a combining of knowledge and ideas is fundamental to managing a problem such as that presented by energy in the years 1975–1995.

But far more important than the recruitment of employees for the operating tasks is the rallying of the personal support of both business and the general population. First to assure understanding of the basic goals and objectives of any major new national development effort, the magnitude of the task, and the reasons for selecting the resource management method applied; and the second, to enlist their wholehearted support in getting the job done.[3]

William Truppner, in his paper cited a number of specific devices that could be adapted from CMP as well as some basic principles as follows:

CMP can be useful in supporting the energy program. Much, however, is not relevant or needed. The Controlled Materials Plan, as it has been developed and administered in the past, is not the appropriate mechanism for the government to employ to support the energy program.

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[3] Appendix 3, p. 21.

The following elements extracted from CMP and related control mechanisms would seem to offer promise as an initial series of steps designed to support the energy program with minimal disruption of other sectors of the economy and minimal threat to employment among members of the non-energy labor force.

1. Publish a specific definition of the energy program, similar to that currently in effect under the Defense Materials System.
2. Require manufacturers and construction firms participating in the program to identify their contracts and purchase orders with appropriate program symbols.
3. Undertake government action (largely Commerce Department) to break bottlenecks, shift shipping dates, reschedule production as necessary, to expedite delivery against identified orders.
4. Summarize new orders, and shipments by program symbol.
5. Take appropriate policy or program action in light of program status information.
6. Issue production directives, as appropriate, to adapt production slates to meet needs of energy program.
7. Employ the CMP "Claimant Agency" concept by assigning programs to specific government agencies, e.g., FPC electric power and gas, Interior shale oil and domestic petroleum.
8. Such agencies would be held responsible for developing programs, estimating materials requirements, justifying proposed level, and "managing" the program after it is authorized.[4]

According to Truppner, the guiding principle should be to move gradually. This kind of development is likely to receive support from the business community, a *sine qua non* for the effective operation of any control system. If a more elaborate system is required in the future, let the events that cause it to be needed manifest themselves first. All control systems develop after they are initiated, not before. People are not smart enough to visualize the consequences of control measures on an economy as huge and complex as that of the United States. The damage has to be done before the repair can begin.[5]

A fuller analysis can be found in the attached papers.

THE CURRENT LIMITED CONTROLLED MATERIALS PROGRAM

Participants from the Department of Commerce and the General Services Administration described the current controlled materials plan, which is limited to meeting priority materials needs of selected agencies identified as "defense agencies". These are authorized to receive preferential treatment under the Defense Materials System (covering the controlled materials—steel, copper, aluminum and nickel) and the Defense Priorities System (which covers products and materials other than the controlled materials). The texts of the pertinent regulations, revised on July 1, 1974, which describe these systems, their purposes and procedures, appear in Appendices 5 and 6.

Defense agencies currently authorized to receive priority shipments under these programs are the Army, Navy, Air Force, Coast Guard, Defense Supply Agency, CIA, Federal Aviation Administration, National Aeronautics and Space Administration, the AEC and the Bureau of Domestic Commerce, acting as a claimant agency for selected programs. (See Schedule II of Appendix 5). The Office of Preparedness in the General Services Administration and the Bureau of Domestic Commerce of the Department of Commerce jointly administer the programs, largely by authorizing allotments of specific amounts of materials for programs and projects contracted for by the claimant defense agencies. At the present time, the Defense Materials System sets aside 4 percent of the nation's supplies of steel, 5 percent of its copper and 15 percent of nickel for the needs of these agencies.

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[4] Appendix 4, pp. 2–3.
[5] Appendix 4, pp. 3–4.

This is the first time in many years, according to the agency representatives, that defense orders are competing with civilian demands. Appeals are coming in for priority authorization from such nondefense agencies as the Internal Revenue Service, AMTRAK, and the Alaska Pipeline project. For example, on September 23, 1974, the FEA and GSA announced that priority allocation of critical materials was being authorized for the Alaska pipeline, under these programs. The announcement said that the decision to invoke the authority of the Defense Production Act was based on views expressed by Congress in passing the 1973 Trans-Alaska Pipeline Act and on a recent finding that, in any war-related emergency, the service of the Alaska Pipeline would be needed for defense requirements and national oil needs.[6]

As described in the regulations, the Defense Materials System and the Defense Priorities System together provide "an established operating mechanism that can be expanded or converted if the need arises."

CONTROL OF MATERIALS BY DESIGN OR DEFAULT

While the participants generally considered Government controls undesirable in principle, they hastened to add that controls may become necessary in practice. Those who remembered the prior CMP experiences agreed that the United States had never planned in advance for controlled allocation. The Government backed into allocation when it became obvious that the costs of not doing it were greater than those of doing it. If current economic trends continue, controls and allocation may be necessary. However, much depends on the state of the health of the economy. In any event, knowledge of those parts of the economic system involved in the supply of fuels and energy delivery is a vital prerequisite for emergency response.

The workshop members agreed that the question, to allocate or not to allocate, assumes too narrow a perspective. The more important question is how to seek stability and economic equilibrium. Part of that process is to decide where the nation wants to go and how it can get there. The public has to be very much involved in the process because its values will determine to a large extent what is feasible within the context of the national resource and environmental parameters. In addition, public tolerance for accepting the costs of alternative courses of expansion and/or conservation seems to be changing.

A LIMITED CONTROLLED PROGRAM FOR THE FUTURE

Is it possible to develop an effective scheme, short of total allocation, to fulfill high priority needs to build the energy facilities for the future? The answer to this question was, "Yes," depending more or less on the conditions set forth in the working papers and outlined above, i.e., size of the program, state of the economy, etc. Many resource problems can be solved through refined action—the scalpel rather than the meat cleaver treatment. However, there are certain conditions and risks involved. Operations which stop short of total allocation do need a total planning program so that possible shortages and dislocations are not left to happenstance. A cautionary note was raised that when limited controls are imposed on a selective basis, there is a tendency to slip into total controls in spite of the intentions of the program and its administrators.

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[6] The text of this announcement appears in Appendix 7.

THE DISLOCATIONS OF A CONTROLLED ALLOCATIONS PROGRAM

What kind of dislocations or disruptions can be expected from a limited or total control system? While they are indeterminable in advance, they fall into the categories of changes in economic patterns of distribution and ownership, labor skills and unemployment, capital requirements and a different mix of consumer products output. They could accelerate the rate of domestic resource depletion, decrease competition and maintain high prices. Their impact would obviously depend upon the scale of application, ranging from limited controls over a few key materials needed to expand energy supplies to comprehensive control of materials throughout the economy.

There is an added dimension in considering a controlled materials program for the magnitude of today's energy demands. Planners usually think of energy in relation to such resources as steel, copper, tubular goods and shovels. However, a massive expansion of energy facilities may also cause dislocations in the environment, water and land use, demographic distribution and the transformation of regional life styles, on a large scale. When this happens in peace-time, an entirely new situation is created which relates back to public support and approval in an increasingly interconnected world. Such an energy expansion program may have significant public opposition if the benefits visible to the public are not greater than the public and social costs.

THE ROLE OF CONSERVATION

It was thought possible, although not probable under present conditions, that conservation and policies to reduce demand could obviate the necessity for materials allocation. In the long run, the internalization of external health and environmental costs associated with energy production could have a dampening effect upon demand. The Federal Government has not been able to develop a philosophy or a practical policy context for conservation. Hardly any of the incentives for increasing consumption that are built into the present tax structure and regulatory administration have been changed. Should there be change in this direction, the basic situation would be fundamentally altered.

POLITICAL DIMENSIONS

The workshop considered the general situation the nation faces in terms of the following historical perspective. The success of the American political system has been its ability to make the country's abundant natural resources available to the people. Business in the free enterprise system has been a partner to this success. Government has not been the doer, it has been the facilitator. As the continued growth of the economy forces the nation to seek needed raw materials and fuels abroad, and as resource scarcities become a characteristic of the world economy, a historical threshold is crossed. Beyond that point, there is only limited substitutability for basic elements like land, water, and energy. In this new situation established constituencies have changed and consensus is breaking down. Dependence on foreign resources and foreign political decisions can force change in habitual patterns of American life, and cause a realignment of the political system.

The nation confronts a great challenge in the face of this evolving situation. Government intervention to help meet the challenge changes ownership and equity. What is important to the public is what happens to distribution and control. Traditionally the public has been very sensitive to changes in these areas. There is no problem with the intentions of an allocation program, but the case has not yet been made for controlled allocation outside the framework of the market.

With reference to the impact of governmental intervention on the private economy, there are two preconditions to an acceptable program. First, the effort has to be open and equitable. Second, there has to be fundamental change and awareness of change in the outside world conditions to make an impact on the private economy. Because these things have not taken place, one must not be sanguine about the effectiveness of an allocation program. At the political level, much effort has recently gone into keeping issues affecting ownership, control and distribution before the public. If controlled allocation is given to an administrative agency, it will take these issues out of the public domain. There is currently not a large enough consensus for this kind of action, and people will not allow it to happen. Real options today are fewer than suggested. Scaling down may be the key problem solver and it may engender greatest public support if the situation continues to deteriorate.

E. MOBILIZING PUBLIC AND PRIVATE SUPPORT

ADMINISTRATIVE REFLECTIONS FROM WORLD WAR II

(By Luther Gulick, President, Institute of Public Administration, New York, 1948)

* * * * * * *

2. *A clear statement of purpose universally understood is the outstanding guarantee of effective administration.*

Translated to military terms this is "the mission must be defined." The war taught us that this rule applies not only to the great purposes of national action, but to each specific activity as well. Many have observed that "national unity" created by the fact of war enabled us to carry difficult administrative tasks, like the conversion of the automobile industry to war production, which could never have been shouldered under other circumstances. It is equally true that a crystal clear and realistic statement of mission, as in the case of the Office of Rubber Director, is equally indispensable for effective administration. The lack of such a defined mission for food production has had the results we are now beginning to appreciate. Many a bold war administrator went forth on a white horse only to be mired in the slough of jurisdictional despond because there was no adequate definition of mission in realistic terms, related to the other activities of the government.

On this point military administration taught us a real lesson. With minor exceptions, no activity was initiated by the military without clear definition, a definition cast in terms of purpose, timing and resources; no organizational unit was set up without a statement of its mission. The success or failure of any man or of any venture was measured against this specific statement of objectives and methods. In administration, God helps those administrators who have a clearly defined mission, and thus the beginnings of authority commensurate with their responsibility.

3. *Translation from purpose to program is the crucial step in administration.*

Important as is the statement of a mission and its definition in terms of time, resources and interrelations, that definition itself accomplishes nothing practically until it is translated into the individual things that are to be done to carry out the mission. While the series of activities which constitute a "program" is perfectly obvious in performing (a) a simple mission, or (b) an oft repeated mission where experience can be the guide, it is a matter of the greatest difficulty in carrying out some substantially novel activity especially if that activity is complicated. In war, most of our missions were totally new to us and were involved, so that their success or failure is a measure of the validity of the techniques used in moving from purpose to performance.

A great deal more study needs to be given to this process of program development. It is a very great art, and demands of administrators not only knowledge and experience in administration, but also the ability to use planning in a high degree and at the same time to act swiftly and energetically on individual matters from day to day so that the decisions fall into a consistent pattern. There is always a strategy of action in which originality and inventiveness are called for because in public administration it is the solution of the new problems which measures the high success of the program, not solely the competent performance of the old activities.

Men differ markedly in their appetite and ability for program development. The planners and professors are generally too inhibited for simple action by their complex intellectual processes; this is also true of professional men generally. The best recruits for this work during the war came from private business and from public life, though business men with all their genius for action were seldom good at dealing with matters of important social and political policy which were at times intermingled with the problems with which they had to deal.

A study of our war experience makes it clear that the central secret of successful program development is the identification of the key controllable item or items in a given situation and then the sure manipulation of those keys. For example, in shifting the economy over to war production what we finally did was to (a) place and finance contracts which gave great incentive to production and conversion, (b) simplify and standardize products, (c) redesign the tax system to encourage war business, (d) prohibit non-war uses of materials and machinery, (e) guarantee or permit the delivery of scarce materials and components only to those who conformed, (f) bring many men from business and labor into government to press for informed and speedy action, and (g) surround management and labor with a co-operative spirit of war enthusiasm. These were the seven keys to war production. The intensely political program to get war contracts into the smaller factories is an excellent illustration of failure in its early days because of the inability of the administrators to discover or lay hold of the key controllable elements. In the earlier days, it seems to have been the conclusion that the solution lay in publicity! The early muddle in war housing was not remedied until an experienced administrator was appointed who decided (a) that the problem was regional in character and (b) that each entire project required a single comprehensive priority.

These are all illustrations of the statement with which I started: translation from purpose to program, from more or less broad objectives to the specific things to be done—this was the crux of administration during the war.

* * * * * * *

13. *The support of public opinion is essential for good administration under American conditions.*

Without the generally informed support of public opinion in this country public administration is extremely difficult if not impossible. We learned this again and again during the war. The number of administrative difficulties and impossibilities which were dissolved overnight on December 7, 1941, is spectacular. Without overwhelming public support, the draft could never have been enforced. The controls of the WPB over materials and production, and of the Manpower Commission over workers not only would have been unworkable without mass acceptance, but would probably have produced just the opposite results from those which were sought, but for that support. An excellent case in point was price control. All through the war, we achieved a high degree of success in spite of legislative delays and management blunders. When a minor but powerful segment of national opinion shifted against control at the end of the fighting, the whole system was thrown into disrepute, many of the price controls started to produce artificial shortages, and the administration fell apart. If nothing else makes us a self-governing democracy, the impossibility of enforcing programs which lack general public backing may be said to guarantee the force of public opinion in this land. If our recent war experience is a sound guide, it is doubtful whether even substantial majorities can enforce nation-wide programs in the face of minority disaffection. Perhaps this makes our democracy more a negative protection than a positive and dynamic force, contradicting Macaulay's famous dictum that our constitution is "all sail and no anchor."

The price of popular support for public administration involves respect for mankind and a continuous process of taking the public into one's confidence. This is a hard lesson, particularly for businessmen who serve the government only during a war emergency. It requires a special aptitude and skill developed only in public life. Except for the political gold fish, working for the public "in a gold fish bowl" cannot be other than an aggravating and disconcerting experience, like painting a landscape, writing a poem, sinking a crucial putt, or proposing to a young lady with a talkative crowd looking over your shoulder and making humorous suggestions. The irresponsible writings of special columnists, which seem so often to be inspired more by the desire to stir up personal conflict and news than to tell the truth or inform the public, is particularly hard to endure. There are essential processes of government which cannot be performed in public especially the negotiation of workable compromises between embattled interest groups and the preliminary elaboration of policies and programs. There are also governmental actions in which timing is an important factor, or in which justice requires that no one shall have advance knowledge of facts or proposed actions. Still it is not safe in the long run to let governmental officials decide for themselves what part of their conduct is and what is not suitable for public exposure. Without doubt more is gained for democracy and sanity by exposure than is lost through irresponsible journalism. Thus we must adhere rigidly and dogmatically to the doctrine of the freedom of the press even though international, political and public libel are beyond effective control, and the competitive nature of journalism makes it difficult to develop responsibility. Once again we must put our faith in education and the gradual rise of mass standards. If this faith is not justified, our whole adventure in self government will probably fail.

14. *Official representatives of organized interest groups are apparently more useful as advisers and as salesmen for government programs than as routine members of the administration.*

During the war we experimented again, as in the days of the NRA, with interest group representation within the structure of government. The War Labor Board had businessmen as representatives of industry, labor leaders as representatives of workers, and professors, politicians and public officials as representatives of "the public." Similarly labor leaders of high standing served in the OPM, the WPB, on the advisory board of the OWMR and especially in the War Manpower Commission. Farmers were represented on various advisory groups of the War Food Administration and the Department of Agriculture by the officers of agricultural organizations, and bankers helped the Treasury on bond sales. In two important areas, our war administrations were actually operated by the officers of the already organized private industry: these were the Petroleum Administration for War and the Office of Defense Transportation, though each of these agencies operated officially under the hand of an experienced public servant—Secretary Ickes for the PAW, and Joseph B. Eastman for the railroads. In all other cases, the officers and paid secretaries of organized industry were specifically excluded as a matter of policy from $1 a year employment or from appointment on industry advisory committees as in WPB and OPA.

What did we learn from this experimentation? It is hard to say, though several observations may be made. Where the industry was drawn in to run itself, as with the railroads and petroleum, relations between the government and the industry were smooth and efficient. It was extremely important, however, to have public servants at the very top able to see and deal vigorously with the internal rivalries of the industry, and at the same time to draw out and use broad and patriotic industry leadership.

From the standpoint of achieving maximum effectiveness in war, members of an industry were at times too concerned with the post-war production and competitive situation, to make the best judges of what was to be done during the war. Good illustrations are the struggles over steel and aluminum expansion and over the Big and Little-Inch pipe lines. However, all-in-all, the industrialists were far more open-minded and public spirited than were the representatives of agriculture who teamed up with their politician allies more than once clearly against the public interest and price control.

The value of participation by labor leaders could not be fully tested because of the internal conflicts within labor, especially between the CIO and AFL. Another difficulty with labor participation arose from the critical shortage of experienced and trusted labor personnel. Few labor leaders could afford to drop their labor union activities and work continuously within the government, apparently because of political insecurity within their own organizations. Thus, with few exceptions, labor participation was limited to the occasional meetings of advisory bodies. In these posts labor made important contributions to the total program, not solely to its organized labor phases, and labor participation served also to mobilize labor acceptance for the various programs involved. Many a plan of the WPB, the WMC, the WLB and the OWMR might have been wrecked by labor except for the fine work which was done from the inside by the representatives of labor in perfecting the program initially, and then in selling the program to the workers of the nation. With a few exceptions, labor leadership and labor economists worked hard to avoid inflation, at least until the end of the fighting. In this regard the leadership seems to have been far more literate economically than the membership.

These experiences seem to indicate that there are both dangers and positive gains from bringing into the government official representatives of organized interest groups. The dangers are found in the inability of such representatives to appreciate the public interest, and the tendency to bring into the government the internal power squabbles existing within the interest group. These dangers can be mitigated by placing at the official head of an organization a public servant of political sagacity, ability and energy, and by using the representatives of interest groups as advisers on policy matters, not as integral parts of the administration. The gains from interest group participation were of two types: first, advice in developing practical and acceptable programs; and second, assistance in selling programs to the membership of the interest group. Both of these services, again, may best be performed when the interest-group representatives are advisers, rather than operating members of the administration. This does not mean that men with a railroad background, or a labor background, or a banking background, or a petroleum industry background should not be employed within the administrative hierarchy of the national government; but it does seem to indicate that such men when employed for administrative work in government should be recruited directly by the government, not designated by the organized interest group, and should then sever their relations with the interest group and become public servants fully and completely. This is, of course, not interest group representation, but rather the employment of public servants who have specialized knowledge of a given field which happens to be organized on the basis of its interests.[11]

This brings me to the final administrative lesson which I wish to draw from World War II. It is this:

15. Truly effective action in administration arises from singleness of purpose and clarity of policy, ardently believed in both by the leaders and by the public in all parts of the country and in all strata of society.

I shall not elaborate this point because it is implicit in most of the other conclusions I have advanced. Still it is a matter of such importance and places such a responsibility upon political leaders and upon top administrators that I cannot fail to give it this added emphasis. Leadership alone does not produce this unity of national purpose, though it contributes to it. Such purpose and policy spring from the culture of a people under the impact of events. Those who make up a nation are conditioned by the past, by the environment, by education and by the insights of great leaders of thought and action. When there is no unity of purpose and policy, administration alone cannot make up the deficiency; when purpose and policy are antagonistic, administration will fail; but when a nation drives forward with unity of purpose, then administration can accomplish the impossible. This is precisely what America did in World War II.

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[11] Consumer representation was initiated at the very beginning of the "defense" period, and continued through the war in the effort to guarantee that the consumers would be protected as the economy moved over onto a war footing. A member of the National Defense Advisory Commission was designated "Advisor on Consumer Protection," in May, 1940. This office was included in the Office of Price Administration and Civilian Supply in April, 1941, and was transferred to the OPM and then to the WPB when that agency was created in January, 1942. However the OPA established the post of Consumer Relations Adviser, and at one stage appointed an "ordinary consumer and housewife" to advise the Price Administrator. The Department of Commerce, in the National Bureau of Standards, also maintained specific representatives of "consumers" in the development of its grade labeling and other standards.

"Consumer protection" within the WPB had a checkered career. In the early days the "Office of Civilian Supply" was chiefly protecting the consumer by urging a more all-out war effort through conversion of autoplants to aircraft production, etc., thus protecting the consumer against the Germans and the Japanese. Later on, after becoming the Office of Civilian Requirements, the agency did protect the maintenance, repair and operation needs of American industry against over-allotments to the military and to lend-lease, and began to develop some semblance of a production program for clothing, house-keeping supplies and other strictly civilian requirements. At the end the program did aid the consumer both through the defense of civilian needs and through the efforts to secure more production of the low price commodities.

But taken as a whole, throughout the war, the major defense of the civilian against unnecessary hardships came more as a result of the central policy decision of the Chairman of the WPB and the President than through any specific defense of his rights and interests by "consumer" representatives. Apparently the real defense of the consumer comes not from special interest representation so much as from broad economic policies based on the public interest as distinct from the special interest of some producer, processor, distributor or user group.

FEDERAL ENERGY POLICY: IN SEARCH OF A NATIONAL ENERGY PLAN

[From Self-Reliance, November–December]

Over the past few months, President Carter's energy plan has been dismantled piece by piece by a hostile Congress. That Congress has no long-term perspective on energy planning is now clear. What must also be noted is that the President's long-term perspective, as demonstrated in his energy plan, was not a whole lot more creative or farsighted.

A national energy plan should have three components. It should present a vision of the future and an explanation of the ethical criteria upon which the plan is based. It should estimate how far we can go toward attaining the vision, in terms of both technology and economics. Finally, it should develop a coherent strategy for encouraging such developments. In other words, a national energy plan should start from a conception of where we would like to be in a given number of years from now and then propose how we can get there.

The Carter plan avoids this strategy. In effect, it avoids the broad implications of long-range planning. Its only concerns are supply and demand: will energy supply match energy demand? There is little consideration of whether or how demand or supply sources should be shaped in order to meet societal goals. The plan feigns neutrality; but, given the present shortage of capital, there can be no neutrality. Both decentralized and centralized systems are capital intensive per kilowatt hour of power generated. We cannot afford to pursue both options. Whether the administration wants to or not, it must choose sides.

WHAT SHOULD A NATIONAL PLAN LOOK LIKE?

The primary criteria, from our perspective, should be that the energy system be democratic and that it encourage the participation of the citizenry in both planning and operation.

A new energy system should place the lightest possible burden on the environment.

Employment opportunities should be maximized and the jobs created should be safe ones.

A new energy system should engender a sense of self-reliance, of community, and of self-confidence. Energy should be generated near the point of consumption, that is, right in our communities. Where feasible, systems should be under the control of local residents.

Decentralized systems should be insulated as much as possible from external pressures. Since reliance upon Exxon is not very different from reliance upon Saudi Arabia, both community and national imports should be lessened.

Based on these considerations, we can begin to envision a future energy system, one that would rely as much as possible on renewable energy technologies—on wind, sunlight, agricultural products, and water. It would be owned, where possible, by users and, where that was not possible, it would be under their direct democratic control.

WHAT SHOULD BE DONE NOW?

The arguments in favor of decentralized energy systems have already been presented in several issues of *Self-Reliance:* Richard Grossman of Environmentalists for Full Employment has discussed the employment benefits of decentralized over centralized energy systems (*issue #7*); David Morris has elaborated upon the economics of solar energy (*issue #5*). We will not review this material. Barry Commoner, Amory Lovins, Denis Hayes and many others have also argued the logic of decentralization quite convincingly. In this article, our concern is different: we want to look at what the federal government could do—today—to lead the nation toward energy self-reliance rather than to back us into the corner of energy dependence and environmental danger.

Over the years, the federal government has developed the power to determine the shape of our energy system. That power is economic, regulatory, and political. It is also the power of leadership. It could be used to encourage the creation of a democratic energy system by the implementation of the following specific policy recommendations:

Recycling

The purchase of recycled materials should be mandatory for all federal procurements. A substantial national solid waste disposal tax should be enacted and all subsidies for the use of virgin materials should be ended. This would encourage more industrial recycling, which has significant conservation potential. According to Harvard geologist Harvey Brooks, the extraction and processing of raw materials now account for about two-thirds of all U.S. industrial energy use or 25 percent of all U.S. energy use. The energy required to produce a ton of steel from urban waste is only 14 percent of that needed to produce the same amount from raw ore. For copper, the figure is about 9 percent and, for aluminum, only 5 percent.

Tax credits

The tax credits that will be passed during this session of Congress did not originate with the Carter administration and the administration has not sought to expand them. Although these federal tax credits will be helpful, they pale in significance when compared to the 55 percent, $3,000 maximum, credit allowed by California (See *Progress Reports*). Unlike the New Mexico and California programs, the present federal tax credit program has no carry-over provision. Yet, taxpayers should be able to spread credits over several years so that persons with lower tax liabilities can still take full advantage of these tax breaks. Without a carry-over provision, any tax credit will favor higher-income citizens.

Capital depreciation

The federal tax code does not permit homeowners to depreciate the capital that they invest in solar equipment. According to the Congressional Office of Technology Assessment (OTA), if homeowners could depreciate their capital investments over a period of three to five years, the effective capital charges would be reduced by one-third. Solar energy systems are genuine utility systems and should be treated as such. As OTA notes, "Since institutional owners of energy-generating equipment are permitted to depreciate their equipment, the current tax policy forbidding homeowners to do this has the effect, if not the intention, of discriminating against the use of such equipment in the house."

Carter's energy plan does ask states to reduce their taxes on solar systems. Property taxes can add as much as 10–25% to the cost of solar systems. The federal government should use whatever leverage it has to encourage the elimination of these and any other taxes that end up discriminating against the use of solar equipment.

Procurement

Procurement is one of the most crucial areas in which the federal government can intervene. The government owns or leases approximately 446,000 buildings in the United States, with a combined floor space of nearly three billion square feet. The cost of heating and cooling these buildings is almost $1.7 billion annually. A recent OTA report concluded that, at present installation prices, "If 10% of the present heating/cooling costs were capitalized—used for debt payments for the purchase of solar equipment—the Government could purchase nearly 100 million square feet of collectors annually." HUD is paying more than $575 million this year to the hundreds of thousands of units of public housing administered by subsidized local housing authorities. If this cost were capitalized, again on a 10 per cent basis, the government could support the purchase of another 30 million square feet of collectors annually. What do these figures mean? The present solar energy goals are to install 420 million square feet of collectors by 1985. Yet, if it were a priority, the government could easily purchase over 700 million square feet of collectors for its own buildings at today's prices ($20 per square foot installed).

The ERDA program

The ERDA (now Department of Energy) solar program should be increased from its present 4% share of the total energy budget. Most importantly, the professional staff in the solar division should be increased. Although the solar budget more than doubled from fiscal year 1976 to fiscal year 1977, the program's professional staff only increased from 45 to 54. As a result of this shortage of contract managers, the staff tends to concentrate on giving out relatively large contracts to large companies for large installations, thereby simplifying the administrative workload.

The current emphasis on centralized systems should be reversed. ERDA has been moving slowly in the direction of supporting small-scale systems. Two years ago, it established an office of small-scale technologies. This year, the agency is beginning to fund research on small wind generators. However, giant applications still prevail and the bulk of solar funding is still going to centralized, large-scale systems.

Preference to small businesses

Contracts from ERDA should favor small businesses. Studies have shown that small companies are generally more innovative than larger ones, that they tend to be more flexible, and that they generate more product per R. & D. dollar. In the HUD Cycle Three program, three companies received almost half of all the contract money awarded. ERDA gives out a large percentage of its contracts to the nation's biggest companies. We suggest that 50 percent of all funding go to small companies. Since solar companies are still small, we recommend that, rather than rely upon the definition of the Small Business Administration (500 or fewer employees, gross sales of $100 million or less), the government should define small solar businesses as those with fewer than 100 employees and gross sales of $10 million or less. Funding should go directly to small prime sponsors, not to larger firms' subcontractors. Further, a program should be established to provide venture capital or low-interest loan money for new small businesses to ensure that their ideas and products reach the marketplace. To rely on the giants of industry for creative ideas would be a serious mistake.

Finally, contracts should be awarded directly to users with the appropriate government agency acting as the contract manager. This is already being done in the HUD solar programs. ERDA's photovoltaic program is moving in the same direction. Until recently, the government relied upon national laboratories to serve as its management intermediaries, for which the laboratories earned sizeable overhead fees. Not only did this inflate costs; it also discouraged innovative combined systems that would have required the overlapped involvement of several separate divisions at ERDA.

These are just some of the changes that should be made. Were federal policy redirected in this way, the climate for developing small-scale, decentralized energy systems would improve markedly. And the goal of energy self-reliance would be more easily attainable.

MOBILIZING THE CITIZENRY

The federal government could have significant impact in another way: it could mobilize people on the local level to join in the great debate about energy futures and to involve themselves in the creation of democratic energy systems. One simple way to do this would be to issue energy goals that are relevant to local communities. The national energy plan advocates installing solar equipment on 2.5 million homes by 1985. This figure is almost as intelligible to the average citizen as is the knowledge that the GNP is 1.7 trillion dollars. Yet, simple arithmetic can bring the statistics down to manageable proportions.

To keep up with the national energy plan, a town of 100,000 people, for example, would need 952 solar hot water systems (57,120 square feet of collectors) by 1985. Assuming a 30% annual increase in solar installations, this means that a neighborhood of 30,000 would have a 1978 goal of equipping 15 homes. A block of 50 homes would meet its 1978 goal by installing one system.

These more intelligible goals could become part of a quota system. On both the federal and the local level, government could establish an award program, highlighting those communities that met or surpassed their goals. One can imagine citizens' meetings—possibly centering around energy workshops—in local schools, churches, or libraries, with local residents gathered to determine their own goals.

Most likely, their goals would exceed those set by the Carter energy plan.

It is all possible. The government has the power. What it needs now is the vision and the leadership. If the search for new energy sources is to be the "moral equivalent of war," we must, as a nation, be clear as to where the battlelines are drawn—and as to which side the government is on. Decentralized energy systems can be the supply source of the future, but that future depends in no small part upon the energy policies of the federal government and upon the degree of pressure exerted upon the government by citizens' groups that believe that the national energy system should be democratic and locally-controlled.

A NOTE ON SECTORAL PLANNING IN A DEMOCRACY

by
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(Excerpt from "A Preliminary Assessment of the President's National Energy Plan" prepared by members of the faculty and staff of the University of Texas at Austin, May 11, 1977)

The effort since 1974 to develop a national energy plan is an exercise in sectoral planning in a democratic society. It involves, inevitably, intimate collaboration between the public and private sectors. In the time ahead we shall, almost certainly, face similar exercises: in water conservation and supply; rail and other forms of transport; agricultural land rehabilitation; certain raw materials; research and development in particular critically important areas. It is worth reflecting a little, in these terms, on how NEP emerged.

NEP was presented to the Congress and the nation after what was evidently an intense effort by a dedicated group working under the direction of Dr. Schlesinger. They were committed to a pre-set deadline. There was evidently little time for consultation; and, from all indications, little serious consultation occurred, despite an apparent solicitation of outside views.

Those who bear inescapable responsibilities for executing the plan, explaining it, and living with its consequences, have, for whatever reasons, been confronted with a fait accompli. This is true, in particular, for governors, labor leaders, and businessmen. State revenues, jobs, production and investment plans are inevitably at stake in a serious national energy plan, as well as new dispositions in every household. Moreover, in our democracy, of diffuse powers and responsibilities, no plan can be executed unless it engages constructively the relevant public and private leaders.

That is the fundamental wisdom of Jean Monnet's observation, in his recently published Mémoires. Speaking of the principles on which the postwar French modernization plan was to be based, he said to General de Gaulle towards the end of 1945: ". . . I am sure of one thing. One cannot transform the French economy without the French people participating in the transformation. When I say the people, it is not an abstract entity. I am referring to the unions, business firms, government departments, all those who will be associated with the plan. . . ." In our great sprawling continental democracy, Monnet's dictum is even more relevant than for more centralized France.

The fact that this dictum was intially violated in the formulation of NEP is not fatal. There will be opportunity in the Congressional hearings for many voices to be heard. More important, as soon as possible the Executive Branch ought to set up a widely based consultative committee on energy within which authentic two-way communication of consequence would occur. The energy problem will be with us a long time; and it will require all hands working in harness if the NEP balance sheet for 1985—or something better—is to come true.

VII

CONCLUSION

We disagree, then, with those who have viewed NEP as "weaker than it looks" (Economist, April 23, 1977) or "not so tough after all" (Wall Street Journal, May 3, 1977). The balance sheet on which it is based would, if implemented, constitute a most serious national effort. And a review of the elements in NEP reveals that only such a serious national effort has a chance to reduce oil imports and thereby protect vital security and economic interests.

But, as now formulated, NEP presents four substantial problems.

The first problem is that it has been presented as, primarily, a plan to conserve energy in equitable ways when, in fact, its balance sheet calls for a rather desperate two-front war with both conservation and production fronts.

The second problem is that its proposed administrative and legislative arrangements conform more to its rhetoric and conservationist strand than to the imperatives of achieving its production targets. Specifically, we believe that the failure to propose firm and prompt resolution of key environmental issues could endanger the coal and nuclear targets; and the failure to provide the requisite incentives and capital flows is certain to endanger the oil and gas targets. The authors happen to believe that we as a nation should seek high rational environmental standards and be willing to pay for them. But uncertainty about environmental standards and delays in settling them responsibly have already exacted from the nation a price running into tens of billions of dollars in imported oil, aside from the secondary consequences of a strained balance of payments. Moreover, in an imperfect world, there are and must be trade-offs. No single criterion in public policy can be absolute.

The third problem centers on an important aspect of equity. NEP is properly sensitive to a hard fact public policy must confront and try to ameliorate; namely, that the proportion of income spent on energy by those at low income levels is larger than at middle and high income levels. There may be simpler and more efficient ways to grant equity than those proposed in NEP, but equity there should be. On the other hand, NEP is quite insensitive to problems of equity as between eastern and western coal-producing states, and as between the oil and gas producers of the South and Southwest relative to the potential producers elsewhere in the country.

The fourth problem is NEP's silence on the appropriate future role of the Federal Estate. We believe a national energy policy must deal with this issue.

A final reflection. As we have reviewed NEP, it has struck us again and again that a truly national effort, on both conservation and production fronts, could have a significant unifying effect on American society. The first instinct of each group and region is, of course, to draw back and defend its narrow interests. And, so long as NEP appeared as a rather limited conservation and coal production plan, this was understandable. Once its production requirements are laid out, however, and the grave consequences of not fulfilling them, there is a much better basis for rallying us all: the Northeast and Middle West; the Western and Eastern coal producers; and the present oil and gas producers who, initially, seemed to be some kind of beleaguered target.

The evocation of the nation's need and capacity to produce has a further consequence. There is a convention in energy plans and studies which is honored in NEP; that is, to divide the world at about the year 1985. After that time, synthetic fuels, in situ coal conversion, perhaps cheaper and less environmentally offensive methods for producing oil from shale will be available. Later, more efficient solar energy devices will emerge, and the exploitation of geothermal power. Perhaps by then we will have learned to deal with the geology of now trapped gas. Certainly, by then processes and machines should be available to economize the use of energy in homes, automobiles, and factories. There are, indeed, technical constraints that will have to be overcome in exploiting all these possibilities. New technology takes time and first rate minds have only begun to work on this array of tasks on a large scale. But if we take President Carter's injunction seriously, that we face the moral equivalent of war, and we evoke the full vigor and technological capacity of the nation, in both the private and public sectors, we ought to be able to bring in some of the post-1985 possibilities before that time. And that could matter. Their contribution to the over-all energy balance sheet might appear small, on both conservation and production sides, but they could make marginal contributions which reduced oil imports to lower levels than those envisaged in NEP. And that, as all hands agree, is the central point of the exercise.

Returning to the opening passages of this paper, it should be recalled that what we and most other nations of the world are engaged in is an effort to scramble through a quarter-century or so of an awkward and somewhat precarious transition from the age of fossil fuels to a new era when our global industrial civilization will be based on some new kinds of essentially unlimited energy sources. In such a transitional situation, no single line of action is sufficient or, in itself, decisive. We must exploit with all the imagination and ingenuity we command every possibility we perceive, both to conserve energy consumption and to expand energy production. We must keep our energy books in balance by a wide variety of economy and production measures, each of which may appear to make a modest contribution to the outcome. But all, taken together, could see us through.

F. ADDITIONAL REFERENCES

"The Legitimate Claims of National Security", by Maxwell D. Taylor, Foreign Affairs, April, 1974.

"Growing Energy Gap Threatens Major Disruptions", by Samuel M. Dix, Excerpts From an Address to the Michigan Legislature's Energy Conference, entitled "The Energy Attrition Impact on Michigan Industry", Energy Users News, October 24, 1977.

"Big Retail Chain May Sell Vehicles: Sears Builds, Tests Electric Car". Washington Post, September 25, 1977, p. M–3.

"Methanol: A Versatile Fuel for Immediate Use" by T. B. Reed and R. M. Lerner. Science, vol. 182, no. 4119, December 28, 1973.

"Alcohol as a Fuel Alternative" by Alfred A. Backer. Congressional Record, November 1, 1977.

"Alcohol for Gasoline", by Jeanne Schinto, Congressional Record, November 15, 1977.

"VW Plans Electric-Gasoline Taxi". Washington Post, June 8, 1976, p. D–11.

"We've Been Asked About Using Alcohol as a Fuel for Automobiles". U.S. News and World Report, January 16, 1978.

"Where Autos Run on Alcohol". Business Week, November 7, 1977.

"Alcohol Fuels: A Major Source of Power Only a Few Years From Here", by Hal Berton, Environmental Action Bulletin, October 29, 1977.

"Alcohol Fuels: An Alternative Energy Supply", by Richard F. Curry, American Motorist, vol. XLVII, no. 3 September/October, 1977.

"Army Lab Finds Gas Substitutes", by Paul E. Steiger, Washington Post, May 5, 1974, p. K–5.

"DOE to Purchase 190 Kilowatts of Solar Cells". Energy, Winter, 1978.

"Wind Energy: Large and Small Systems Competing". Science, vol. 197, September 2, 1977.

"Wind Research Better Investment Than Solar". Energy Digest, vol. VIII, no. 1, January 15, 1978.

"A New Promise of Cheap Solar Energy". Business Week, July 18, 1977.

"Its Time is Coming: Coal for Processing". Chemical Week, November 2, 1977.

"A Program for Maximizing U.S. Energy Self-Sufficiency", by Henry R. Linden. Energy Systems and Policy, vol. 1, no. 1, Fall, 1974.

"Mobil Patents Way to Convert Coal to Gasoline", by J. P. Smith, Washington Post, January 14, 1977.

"Gasoline-From-Methanol Passes Pilot Test". Chemical Week, January 25, 1978.

"Shale: The Answer to Domestic Oil Supply?" Business Week, January 25, 1978.

"Existing Small Dams May Hold Key to Substantial Increase in Hydropower Generation". Professional Engineer, vol. 47, October, 1977.

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